ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Siemens Brothers & Co., Ltd.

The ORDINARY GENERAL MEETING was held on Tuesday, the 11th instant, at Winchester House, Old Broad Street, Mr. G. MURE RITCHIE, the Chairman, presiding.

The Chairman said that during the past year the Company had adhered to its past policy, and the volume of the business done exceeded that of 1916 by about one-third. The expansion in output occurred principally in insulated wires and cables, ebonite and batteries. In regard to the development of automatic telephony, which the Company foresaw before the War, the advantages of eliminating the human exchange operator had been demonstrated in practice and all technical difficulties surmounted, and they were equipped to provide large exchanges for public service, and also private exchanges of 25 to 500 lines. Notwithstanding the demands of War-work, they had completed a semi-automatic exchange of 1,000 lines at Port Adelaide for the Commonwealth of Australia, and a full automatic exchange of 1,300 lines at Grimsby for the G.P.O., while good progress had been made with a full automatic exchange of 950 lines for Stockport, also for the G.P.O. Many private exchanges had been established in munitions factories, and had given every satisfaction.

After speaking of the cordial relations existing between the Company and the workpeople, the Chairman went on to say that the year's profit of £208,534 showed substantial increase over that of 1916, due to the very much larger volume of business done. An interim dividend of 10 per cent., free of Income Tax, had been paid, but no further distribution for the year 1917 could be considered until the Government claim for excess profits duty had been adjusted.

The Balance Sheet showed £764,534 for materials, manufactured goods and work in hand. This was more than double the pre-war amount of £377,385, the increase being due entirely to the growth of expenditure on orders in hand, which at 31st December exceeded in value £1,500,000.

An important asset was the holding of the entire issued capital of Siemens Bros. Dynamo Works, Ltd., namely, £200,000 in shares and £200,000 in debentures. At the outbreak of war the share capital of Siemens Bros. & Co., Ltd., was £600,000 with £150,000 of 4 per cent. debentures, nearly all the shares and about one-third of the debentures being held by Germans. Moreover, the German shareholders had supplied funds to meet the capital requirements of the growing businesses of the two companies. When war began, the entire German interest in the shares and the additional capital referred to was vested in the Public Trustee, who took steps to realise it by sale to a British buyer, and on 14th December, 1917, the share capital of Siemens Bros. & Co. was purchased by Messrs. C. B. Crisp & Co. The contract provided for the issue to the Public Trustee by the Company of £1,330,000 of 4½ per cent. debentures to provide for the repayment of capital (other than share capital), and the participation in the 4½ per cent. debentures employed in the business by the former German owners; and the Public Trustee had a right after the conclusion of peace to call for the redemption of these debentures on one year's notice. Subject to such arrangement, they were redeemable by annual drawings calculated to extinguish the whole in 25 years from the date of issue.

Following this arrangement with the Public Trustee the Board was reconstituted, and now consisted of Mr. G. Mure Ritchie (Chairman), Sir William Bull, M.P., Sir Clifford Cory, M.P., Lord Queenborough, Mr. H. J. Thomas and Mr. G. Chauvin (Managing Director). The new Board had devoted attention to many questions concerned with the development of Siemens Bros. into a great national manufacturing asset, leaving little time for discussion of a scheme of rearrangement of the share capital. The Board, however, recognised the advisability of changing the capital arrangements so as to establish equilibrium between share capital and debenture debt, and at an early date the shareholders might be asked to approve a scheme for increasing the share capital to £1,500,000 (or even more) in £1 shares, of which a substantial portion would remain in reserve for future developments: but as to £400,000, if issued for cash, the proceeds would be available for the retirement of a corresponding amount of debentures. If the matter were carried through on the lines thus indicated, the joint concerns—Siemens Bros. & Co. and Siemens Dynamo Works—would be represented by an issued share capital of £1,000,000, with £150,000 of 4 per cent. debentures and about £1,000,000 of 4½ per cent. debentures, the latter being held by the Public Trustee. These readjustments were all subject to the consent of the Authorities concerned, but he could go so far as to say that, as the Board of Trade wished the Company to be so assisted as to ensure its future expansion in British hands, they were justified in believing that sympathetic consideration would be given by the Authorities to their proposals for the financial reconstruction of the Company when they were put forward.

Dealing with Siemens Bros. Dynamo Works, Ltd., entirely owned by Siemens Bros. & Co., the Chairman said that the turnover in 1917 increased in the United Kingdom and decreased overseas, as compared with 1916. The value of unexecuted orders on 31st December was £1,145,000. Siemens Bros. & Co. and the Dynamo Works had purchased £50,000 of War Loan, and had provided several thousands of pounds to give temporary assistance to War Savings Associations for the workpeople.

Since the entry of the new directors into office, negotiations had been inaugurated with other companies doing similar industrial business with the object of bringing such manufacturers together for the reduction of unnecessary competition and the avoidance of duplicating machinery, workshops and offices. Co-operation would make for the more continuous running of plants with the attendant advantages of cheaper production, increased efficiency and improved quality of the work done, avoiding unnecessary expense in storage, selling organisations, and reducing the duplication of stocks to a minimum. An even more important advantage aimed at was the amalgamation of designing offices and interchange of experience, designs and methods to the promotion of economy and efficiency. Such industrial alliance would, moreover, make it possible to carry out complete installations within the allied group. An alliance of this nature had already been arranged with Messrs. Dick, Kerr & Co., Ltd., in the field on dynamo installations in all its ramifications, and other alliances were contemplated. He moved the adoption of the report and accounts, and the motion was unanimously carried. A vote of thanks to the Chairman concluded the proceedings. L 777

The Manchester Steam Users' Association.

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Membership is not confined to residents in London
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JAMES HARRINGTON, K 6
85, Salisbury Road, Harrow, Middlesex.

The Council of the Chartered INSTITUTE of PATENT AGENTS

by a resolution of the 4th day of June, 1918, hereby authorise Fellows of the Institute to make, as from the 30th of June, 1918, an additional charge of 10 per cent. on the scales of fees recommended by the Council, to cover the additional expenses they have to incur in consequence of the war.
H. HOWGRAVE GRAHAM,
Secretary and Registrar. L 734

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open to Engineering Students under 26 years of age and of the value of £100 per annum for three years, tenable at the Imperial College of Science and Technology or other place of Higher Education, will soon become vacant.
Applications should be sent to the CLERK, WISEMAN AND WITHERS FOUNDATION, The Woolwich Polytechnic, S.E. 18, from whom further particulars may be obtained. L 746

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(By Order) DUNCOMBE MANN, L 778
10th June, 1918. Clerk to the Board.

THE MEXBOROUGH AND SWINTON TRAMWAYS CO., are prepared to receive

Offers for the following Boilers and MACHINERY:—

One Davy Paxman Boiler, 14 ft. by 8 ft., 5000 lbs. evaporating capacity, insured for 160 lbs. working pressure, complete with usual fittings and under-feed mechanical stoker in good condition.
Two Boilers, as above, but without stokers.
Various lengths of steam, exhaust, and feed water Piping and Valves.
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The Plant can be seen at the Generating Station of the Company, Dale Road, Rawmarsh, by appointment with the Engineer at that Station. Offers to be made for the Plant as now standing to the SECRETARY, 62-63, Queen Street, London E.C. 4. L 774

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(b) Two LECTURERS in Civil and Mechanical Engineering. Salary £400 per annum, with quarters for residence. Five years' agreement. Passage money of £100.

The selected candidates will be required to take up their appointments as early as possible after September, 1918.
Applications should reach Messrs. PREECE, CARDEW, SNELL & RIDER, 3, Queen Anne's Gate, Westminster, S.W., before Friday, June 28th, from whom further details of each appointment may be obtained. L 691

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Education Office, Darlington, Secretary.
June, 1918.

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Principal J. F. HUDSON, M.A., B.Sc.

Mechanical Engineering Workshop INSTRUCTOR and DEMONSTRATOR

REQUIRED in September. Commencing salary £170.
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to superintend the maintenance of the engine and electric plant, also the building of King's College Hospital. It is essential that he shall have a thorough knowledge of Diesel engines and a good general knowledge of engineering and the direction of the staff in the several departments.
The salary offered is at the rate of £400, rising to £500 by an annual increment of £25 per annum, and in addition a war bonus of 12½ per cent.
Applications, stating age and qualifications, should be forwarded to the SECRETARY, King's College Hospital, Denmark Hill, S.E. 5, by Wednesday, 19th June, 1918.
By order of Committee of Management,
RICHARD J. COLES, Secretary.
7th June, 1918. L 757

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large industrial works within 20 miles of London. Plant to be looked after is new and modern, embodying all latest improvements comprising conveying, crushing, hydraulic machinery, steam and electric power plant. Applicants having previous experience with plant running continuously 168 hours per week will receive special consideration. Expert chemists and allied technologists operate specialised departments. Salary commensurate with experience and ability of applicant.—Applications, stating full particulars of training and other experience, to be sent to L 762, Offices of ENGINEERING.

Capable, Well-educated Engineer,

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State full experience, age and salary required. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5339. L 615

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Midland firm engaged on Aero Engine work, first-class Jig and Tool INSPECTORS. State full particulars of experience. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5200. L 627

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REQUIRED immediately for diagram, layout, and record work, by controlled establishment with large H.T. and L.T. 3-phase A.C. system. Good wages and prospects for suitable man to qualify for permanent post as Assistant Engineer. No one already on Government work will be engaged.—Apply at your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5450. L 737

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on Tyneside, accustomed to general industrial building construction and lay-out of machinery and plant. No person already on Government work will be engaged.—Apply, stating age, experience, and salary expected, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5474. L 728

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INDUSTRIAL JAPAN.

COAL, IRON, STEEL AND SHIPBUILDING.

WITH ample supplies of coal, iron ore, copper and tin, an advantageous geographical situation, magnificent harbours, a favourable climate, an energetic and adaptable population, and an exceptionally businesslike Government, Japan is rapidly becoming one of the world's leading industrial countries.

In the first place, the already proved coalfields of Japan contain, at a moderate estimate, 2,000,000,000 tons, mostly of a bituminous quality which will make very good coke. Before the war an annual output of more than 15,000,000 tons had been attained, at a pit-mouth price of less than 10*s.* a ton, and good Japan "lump" was being supplied at several coaling stations in the East at about 14*s.* a ton. The coal seams vary from 3 ft. to 25 ft. thick, and are mostly well situated. Many of the seams are worked by incline, though several shafts have been sunk during the last few years, some to a depth of 1,000 ft. One mine, the Manda, with a shaft 896 ft., has a daily output of more than 1,000 tons. Nearly all the cutting is done by hand, but machinery is being introduced as rapidly as circumstances permit. In the north, in the island of Hokkaido, there is an extensive coalfield with 13 seams, the thinnest of which is 3 ft. thick. In the same island a field with 20 seams has been discovered, of which at least five are workable, whilst in still another district there are three excellent seams, one of which is 25 ft. thick. In the south, in the island of Kyushiu, the coal measures are at least 30 miles long, by 8 miles to 16 miles wide, and were estimated ten years ago to contain 600,000,000 tons. By the way, it may be mentioned, that in spite of a restricted employment of machinery, the output of the Japanese coal mines, per man employed, is just about equal to that of this country, viz., 250 tons a year. There is every prospect of a rapidly increasing production, ample to meet all the needs of Japanese industry, and to allow of substantial exports to various Pacific and Indian Ocean coaling stations.

There seems no comprehensive estimate of the iron ore reserves of Japan, but some very rich and extensive deposits have been found in the south-west, near the port of Sakai, about 100 miles from Osaka, and a similar distance from the coalfields of Kyushiu. Considerable deposits have also been located near the ports of Miyako and Minato, in the north-east, as well as in the central districts near the goldfields which lie between Tokio and the West coast. But so far, Japan has relied almost entirely upon iron ore imported from China. The mines on the Tayeh have supplied more than half the iron ore consumed in Japanese furnaces. This ore, which yields a remarkably high percentage of iron—50 per cent. to 65 per cent.—and the supply of which is practically inexhaustible, is brought from the Pinghsiang mines, about 200 miles up the river Tayeh, down to Hankow in steel lighters, and then shipped in larger vessels to Japan, *via* the Yang-tse-Kiang and the Yellow Sea. Incidentally it may be mentioned that pig-iron and steel and various steel products are made at the Hanyang iron and steel works, 600 miles up the river. Besides drawing fully half its ores from China at the present time, Japan is importing considerable quantities from Korea and Manchuria. About half the proved reserves of ore in China are controlled by Japanese capital, and another syndicate is negotiating for control of iron ore lands in the province of Nankin. In ordinary times the freightage on the ore from the Yangtse to Wakamatsu was about 3 yen, or 6*s.* per ton. Ten years ago the cost of producing pig-iron in Japan was very nearly 5*l.* per ton, and steel ingots 8*l.* A little time before the war the cost of pig-iron production had been got down to about 2*l.* per ton. Whilst making arrangements for increased importations of ore, Japan is preparing to utilise its own reserves on a considerable scale. It is believed that the island of Hokkaido will become an important iron-mining and smelting district. Japan also possesses large reserves of more valuable ores. More than 5,000 tons of chrome, 10,000 tons of manganese and 37,000 tons of copper ore have been raised in a year.

As recently as 1907 Japan produced only 43,000 tons of pig-iron and 4,500 tons of steel in the year. Last year the production was about 500,000 tons of pig-iron and 750,000 tons of steel—an increase of 50 per cent. over that of 1916, and it is estimated by the Government Mining Bureau that in 1918 the production of pig-iron will reach 745,000 tons, and that of steel 1,155,000 tons. Great efforts are being made to increase the supply of ship-building materials. Last year Japan imported 250,000 tons of ship plates, and 50,000 tons of rails, from the United States. The supply was much below the demand of the shipbuilding yards, and to-day scores of building berths are empty for want of bars and plates. Before the war Japan was importing nearly 5,000,000*l.* worth of steel annually. In 1909 it was stated in a Government document that "As regarded the home supply of shipbuilding materials great hopes were entertained that their builders would before long have ample supply of the necessary materials from the Imperial Steel Works at Wakamatsu, and thus be freed from the disadvantages of importation." The history of these works is interesting. The initial outlay was unnecessarily heavy, and that has handicapped the enterprise; but the Government has pushed on with the business. Ten years ago the plant was employing 7,000 men, and comprised three blast furnaces, with a combined daily capacity of 450 tons of pig-iron, three Bessemer converters of 10 tons capacity each; a 160-ton mixer and three cupolas; cogging, rail, bar, rod, plate and sheet mills; crucible steel plant; wire-drawing plant; galvanising and corrugating plant; boiler, engine and bridge shops. Rifles, heavy artillery and big guns for battleships were also being made. Since then the works have been extended, and new Government plants have been erected at Mororan and Kure. The principal plant is being further extended under a scheme estimated to take five years to complete. The Kure Dockyard is being equipped with new boiler-plate rolling mills. The Government is also making extensions at Edamitsu with a view to producing 120,000 tons of plates annually.

Private enterprise, with State encouragement, is also making strenuous efforts towards the industrialisation of Japan, and it is hoped to attain a production of more than 2,000,000 tons of steel a year before 1920. The Japan Steel Company, now the largest of private concerns, is doubling its capital of 1,500,000*l.* in order to extend its works at Muroran, in the Hokkaido. The Mitsu Bishi Dock Company, one of the chief shipbuilding concerns, has started a steel works of its own in Korea. The Kawasaki Dock Company has built plate and bar mills at Kobe. The new Asano Shipbuilding Company, of Tsurumi, is laying down a rolling mill. The Toyo Seitetsu Kaisha, capitalised at nearly 3,000,000*l.*, has purchased an extensive site in Kyushu for a new plant, commenced in April, which will bring the iron and steel-making capacity of this company up to a rate of 170,000 tons a year. The Toyo Kisen Kaisha, which is extending its ship-building yard, has formed a subsidiary company to erect two steel-making plants—one at Chinnanpo, in Korea, at a cost of 1,000,000*l.*, and the other in Japan, near Yokohama, at a cost of 500,000*l.* These two plants are designed to produce, between them, 250,000 tons of shipbuilding materials annually. Another syndicate has purchased land at Mansok-dong, Chemulpo, Korea, for an iron and steel works. The Fuji Seiko Kaisha has been floated with a capital of 600,000*l.* What is described as a "gigantic project," by the well-known Kuhara family, is being started in Osaka for the manufacture of iron and steel. New steel works are also about to be erected at Kurosaki, in Hakata Bay, designed to produce and work up into steel nearly 500,000 tons of pig-iron a year, besides which the concern will import pig-iron from the famous Hanyhaing Works, in China, and is promised 60,000 tons a year from the Imperial Foundry. Half the capital is being provided by Mr. Keiichiro Yasukawa, the well-known Kyushiu mine owner, and the other half by shareholders of the Hanyhaing Company.

Besides these enterprises chiefly concerned with the supply of shipbuilding materials, there is the newly-established Japan Steel Pipe Company, with works planned for an annual output of 60,000 tons, whilst the South Manchurian Railway Company is starting a steel works in Manchuria, and a group of smaller concerns are going in for the manufacture of steam and water turbines, steam, gas and oil engines, traction and industrial motors, electrical goods, general tools and implements. The British Embassy at Tokio recently reported the passing of a law, to come into operation at the beginning of September last, having for its object the encouragement of the iron industry in Japan. Its main provisions are: (1) That iron and steel works with an output of not less than 35,000 metric tons per annum will have the right to expropriate property on which it is necessary to locate works; and (2) that works turning out not less than 5,225 metric tons per annum will be exempt for eleven years from business and income taxes, and from all forms of prefectural, local and municipal taxation, as well as being allowed to import free of duty the machinery, &c., required for the works. This law has resulted in the launching of a number of new undertakings. Supplementary regulations provide that an iron works which is entitled to the various benefits must be a business connected with the production of pig-iron, steel, rolled steel (including rails and fishplates), materials for making forged or cast-steel manufactures, or such by-products as are indicated by the Minister of Commerce. The Imperial Railway Board recommends the construction of 1,135 miles of new railroad, at an estimated cost of 18,000,000*l.*

Meantime, an association of iron and steel importers has been formed in Japan with a view to securing the necessary supplies for the iron, steel and shipbuilding trades, as the home supplies are still so inadequate. It was recently stated on high authority that no fewer than 113 shipbuilding berths of various sizes were unoccupied in Japan for want of materials. The Japanese Government is also making urgent representations to the United States to relax the recent embargo on exports so far as shipbuilding steel for the Japanese yards is concerned. The plans of the 48 chief shipbuilding yards provide for the construction, this year, of about 100 merchant vessels, aggregating 800,000 tons, but unless increased importations of material can be secured it is doubtful whether more than 500,000 tons will be completed.

Japan's mercantile marine now well exceeds 2,000,000 tons. The official figures for the end of 1916 gave 2,170 steam vessels, aggregating 1,704,785 tons, and 9,187 sailing ships of 572,403 tons. In 1916 the Japanese yards completed 250 merchant vessels of 246,000 tons—more than twice the tonnage attained in any previous year—and when the figures for 1917 are available it will be found that the 1916 output has been much exceeded, in spite of the great difficulties in the way of importing materials.

Japanese shipbuilding, like the steel industry, owes much to State assistance. As recently as 1894, only 84 steamers of 1,000 tons or more were owned in Japan, and of these only one had been built in that country. But in 1896 the twin trades of shipping and shipbuilding received a great stimulus by the enactment of the now famous Shipping and Shipbuilding Subvention Law, which became operative in 1897. In the last year preceding the payment of subsidies the total output of Japanese yards was only 5,860 tons of steam and 1,061 tons of sailing (ocean-going) vessels. By 1900 the tonnage launched had increased to 15,380 steam, and 17,873 sailing. For 1913, the last year before the war, the total output was 63,664 tons, nearly all steam. In 1914 the tonnage was 85,861; in 1915, 106,388; in 1916, 246,000; and last year something considerably over that tonnage. For 1917 the vessels completed under the terms of the Subsidy Law—that is, ships of not less than 1,000 tons—numbered 69, with an aggregate tonnage of 299,684 tons. It is estimated that with small craft, together with wooden ships of 1,000 tons or more not entitled to subsidies, the total output for the past year will have been at least 400,000 tons On January 1, 1918, there was under construction in Japanese yards not less than 1,330,000 tons, though building was being delayed through shortage of materials, and many berths were empty. Japan

now ranks third in tonnage built, and fifth in tonnage owned, amongst the world's nations.

Under the Subsidies Law the output of the yards increased from 13,000 tons in 1897 to 78,000 tons in 1908, the subsidies in respect of both shipping and shipbuilding having increased in that period from 1,944,000 yen to 13,166,000 yen. In the next year, 1909, the output declined to 55,000 tons—a decrease of 23,000 tons on 1908. That was considered unsatisfactory, and a new Subsidies Act was carried. This came into force at the beginning of 1910, and the twin trades received a fresh impetus. The new law was framed to give smaller subsidies in respect of navigation, or shipowning, but more liberal terms in respect of the building of large vessels. Bounties of from 11 yen to 22 yen per ton of gross measurement were paid in respect of steel ships of not less than 1,000 tons, according to type, with an additional bounty upon the engines of 5 yen per indicated horse-power. Under the old law the bounty was a round 20 yen per ton for vessels of not less than 700 tons gross.

The new law aimed at the maintenance, or development, of certain specified trade routes, and the encouragement of larger and faster ships. It left the Minister of Communications discretion to refuse bounties to vessels of less than 3,000 ton if they were of less than 12 knots speed, or were employed upon undesirable routes. He was also empowered to grant increased rates of bounty up to 25 per cent. on the base in respect of vessels run on trades which might not be profitable, but which it might be specially desirable to maintain for Imperial reasons. An age limit was also imposed; and speed was considered. Ships built of steel in Japan, and owned in Japan, of not less than 3,000 tons gross, of not less than 12 knots per hour, and not more than five years old, were subsidised at a rate of 50 sen—that is, half a yen, or about 1*s.*—per ton per 1,000 nautical miles run. For every knot of speed beyond 12 per hour there was a bonus of 10 per cent. on the base bounty. On the other hand, when a ship exceeded five years of age, there was a 5 per cent. reduction for every year until fifteen years were reached, when the subsidies might be withdrawn by the Minister of Communications. The Minister was also authorised to grant subsidies at half the ordinary rates to foreign-built vessels if he thought fit. In the twenty-one years in which the Subsidies Acts were in force the amounts paid totalled 160,000,000 yen—say, 16,000,000*l.* Recently—with the shipowners enjoying abnormal profits on account of the war, and in view of the high prices they are prepared to offer for new vessels—a new law has been carried suspending the payment of the subsidies in respect of the building of ships. The Osaka Shosen Kaisha, owning 378,000 tons of shipping, and with a paid-up capital of 3,106,250*l.*, had a profit of 1,834,724*l.* for last year, after allocating 121,500*l.* to the insurance fund, 162,000*l.* to the repair fund, and 101,000*l.* for depreciation of the fleet. Generally the profits of Japanese shipping have been, to quote *The Financial Review of Reviews*, "immense."

Regarding the rapidly increasing shipbuilding resources of the "Britain of the East" it may be mentioned that the country has about 120 berths capable of taking vessels of 1,000 tons or more. The capacity has been increased threefold since the war started. Perhaps the most notable of the Japanese shipyards is the one on Nagasaki Harbour, founded by the Government in 1857, but sold to a private capitalist in 1884. Shortly after the establishment of this State enterprise two or three yards and engine works were started by private people, but little or no financial success was met with. In 1868 the Imperial yard was placed under the management of an Industrial Department specially formed for the purpose. This body went in for merchant as well as naval building. Then a second Imperial yard was started at Kobe, and the best of the private plants were nationalised. The builders of fishing and other small craft tried to approach the Western style of construction, but the financial results were mostly disappointing. As mentioned above, in 1894, out of 84 Japanese steamships of 1,000 tons or more, only one had been built in Japan. But the Subsidies Law changed the situation. However, in 1884 the Imperial yard at Nagasaki became the private property of Baron Iwasaki, and is now known as the Mitsu Bishi Works. When it was denationalised in 1884 it employed 800 men, after twenty-seven years of State control. When the present war broke out it employed about 10,000 men. Last year this company launched 10 steamers ranging from a tonnage of 3,163 to 7,317. At the beginning of this year the firm had 13 steamers of an aggregate tonnage of 63,000 on hand. Before the recent war-time extensions, the principal yard of this concern covered 115 acres, it had nearly 1½ miles of water frontage, three dry docks of 350 ft., 510 ft. and 714 ft. in length, a patent slip 750 ft. long, and seven building berths ranging from 185 ft. to 700 ft. long. Ten years ago this firm built two of the finest turbine passenger vessels of the day. The company has another yard at Kobe.

The principal yard of the Kawasaki Dockyard Company, at Kobe, like that of the Mitsu Bishi, was originally founded by the Government, but sold into private hands in 1886, and subsequently passed to the present ownership in 1896. Until about ten years ago only torpedo craft and small gunboats were built here for the Japanese and Chinese Governments, but in 1908 two merchant vessels, each of 8,600 tons, were launched. On the eve of the war this yard had a frontage of nearly a mile, and four building berths of from 400 ft. to 600 ft. in length, besides several for smaller craft. The company built its own steel foundry about ten years ago. Last year this concern launched 21 steamers of from 1,570 tons to 9,400 tons. It has just lately built a new plate mill. Perhaps third in rank of capacity is the shipyard known as the Osaka Ironworks. This was founded by an Englishman, Mr. T. H. Hunter, in 1880, and was still owned by him less than ten years ago, and for anything the writer knows to the contrary Mr. Hunter is still living and controlling the yard. The concern comprises, besides the principal yard at Sakurajima, covering 16 acres, with a water frontage of 1,000 ft., and three dry docks, engine shops at Ajikawa Guchi, and repairing works at Temposen. Last year this company built 19 ships of from 1,212 tons to 7,789 tons. Altogether there are over 200 shipbuilding and repairing yards in Japan, though most of them are limited to the construction of fishing and other small craft. About a dozen can build modern, ocean-going ships. Besides the three companies just named, mention may be made of the Uraga Dockyard Company, which launched eight vessels of about 8,000 tons each last year; the new Ansano Company, seven ships of about 900 tons; the Yokohama and Fuginagata Companies, which launched several vessels up to 3,000 tons. Of the four Imperial yards, the Kure and Yokosuka establishments have each accommodation for the construction of the largest battleships and cruisers, whilst the Sasebo and Maizuru yards are specially adapted for the building of smaller types of war vessels. These four yards, needless to say, are furnished with every appliance necessary for the rapid handling of materials. At Kure is the Imperial Arsenal, with its armour plate and big-gun shops as well as the shipbuilding yard. At Sasebo there are three huge dry docks.

A notable development in the Japanese shipping and shipbuilding trades is a movement towards a community of interests for securing trade after the war as well as for obtaining supplies of material during the war. Several of the purely shipbuilding concerns are combining in order that the various yards can be put exclusively on the classes of work for which they are most economically adapted, and combines are being formed among colliery owners, iron mining concerns, steel works and shipbuilding firms, with a view to bringing all phases of production under single managements. The methods of the German cartels in the co-operative buying of raw materials and disposing of finished goods are also being carefully considered. But primarily the difficulty is that of securing supplies of shipbuilding materials, and for this purpose such leading firms as the Mitsu Bishi, the Kawasaki, the Asano, the Uraga and the Yokohama dockyard companies have formed an association called the Sempaku Kyokai.

The Secretary of the Swedish Legation at Tokio reports that with a view to the further encouragement of the shipbuilding industry it has been decided to establish a loan bank in Japan for advancing money on the security of ships under construction, on lines similar to the Ship Mortgage Bank of Hamburg. The nominal capital is to be slightly over 2,000,000*l.*, but the concern will be able to enter into engagements up to ten times this amount, and efforts are being made to obtain Government assistance, or a guarantee.

Regarding the possibilities of Japanese competition with ourselves generally, it may be observed, first, that current extensions of manufacturing and shipbuilding capacity, and of additions to our Eastern ally's mercantile fleet, are being made under abnormal conditions, at enormous cost for materials, which means most extravagant capitalisation, and that the enterprises involved will thus find themselves heavily burdened with capital charges when prices and freights become anything like normal again, whereas our capitalisation will be little or no more, per ton of either manufacturing or shipping capacity, than it was before the war; and, secondly, that through shortage of plant, machinery, and skilled labour, it will be many years, even under the most extraordinary circumstances, before Japan can offer us any really serious competition, save in limited lines, or markets.

FERRO-CONCRETE SHIPBUILDING.

ONE of the pioneers in the ferro-concrete shipbuilding industry, Mr. Fougner, the director of the Fougner Steel Concrete Shipbuilding Company, in Christiania, has recently returned from the United States and has given some interesting information about the rapid progress of this new industry in America. When he arrived there in November, 1917, concrete vessels were entirely unknown, excepting some few lighters and sloops. Sea-going vessels with self-propelling machinery had never been attempted. Mr. Fougner had several conferences with the authorities, and as a result the Shipping Board in January entered upon a contract with him for the building of six ferro-concrete vessels, each of 3,500 tons deadweight. Plans have since been drawn for a standard type of 7,500 tons. All the machinery and equipment is supplied by the Shipping Board under the supervision of the Fougner Concrete Shipbuilding Company, near York. This company is a daughter concern of the Fougner Steel Concrete Shipbuilding Company, Christiania. The American company, besides these contracts for the American Government, has also secured contracts from the American Navy and several private firms. The American Government has formed a special section of the United States Shipping Board for the building of concrete vessels, and more than 50 engineers have already been engaged for managing this industry. The American Fougner Company is constructing a yard intended for the building of large vessels for the Shipping Board in addition to the yard in New York. Experiments with different kinds of steel for the reinforcement of concrete in concrete vessels have, it is stated, shown that steel used for this purpose ought to be considerably stronger and of better quality than the material generally used for reinforcement purposes in the more ordinary constructions of houses and bridges. The largest ferro-concrete vessel so far launched in Europe, took the water a few weeks ago from the Greaaker ferro-concrete shipyard, Norway. It is 1,000 tons deadweight, and the lines are said to be very pleasing, the design having been undertaken by the Frederikstad Engineering Company. The length between the perpendiculars is 52.5 m., breadth 9.7 m., height 5.4 m. There are two Bolinder motors, each of 160 effective horse-power. The ferro-concrete shipyard, at the time, obtained permission from the Norwegian Commercial Department to build this vessel as an experiment without class, but when the Norwegian Veritas took up the classification of concrete vessels, the yard, in the interest of the contracting owners, decided to revise the drawings, so that the vessel could obtain Veritas class, which meant material advantages as regards insurance both of vessel and cargo. The vessel has been classified "1.A.1. concrete lighter. Experimental. For carrying coal and timber."

VISCOSITY DETERMINATIONS IN ABSOLUTE UNITS.

THE frictional resistance which a fluid offers to shearing, i.e., to the relative sliding of parallel planes without change of their mutual distance, is measured by the tangential force per unit area required to produce unit rate of shear between two planes at unit distance apart. The quotient-tangential force/shear is known as the coefficient of viscosity or true viscosity η. In absolute viscosity determinations a fluid is forced through a long horizontal capillary; the η is deduced from the volume of fluid passing in unit time and expressed in dyne-seconds per square centimetre; this unit has been called the "poise." The experimental basis of these determinations goes back to Poiseuille, 1838. The technical apparatus for viscosity measurements, known as viscosimeters or viscometers, are efflux-instruments; the time is measured which it takes a certain volume of the liquid to flow from a cup through a short vertical tube into a flask. None of these instruments satisfy theoretical conditions, even if well made; the units are arbitrarily chosen, and the ratios of the viscosities of two oils, as measured by two different viscosimeters, may not be the same. The results are hence not directly comparable, and there is a growing demand for expressing the results of the standard instruments in c.g.s. units. For this purpose certain corrections have to be applied to the values observed. These corrections depend upon the type of instrument; we will briefly describe the three oil viscosimeters in widest use: Sir Boverton Redwood's, the standard instrument of this country; Carl Engler's viscosimeter, in common use on the Continent and also in America; and the Saybolt instrument, which has been adopted by the Standard Oil Company.

All these instruments consist of a cup, provided with a water or oil jacket and with an opening, a jet, in the bottom, normally closed by a valve rod or by a cork, through which the oil flows into the measuring flask; filling marks, thermometers and stirrers are accessory parts; the viscosimeter is calibrated with some standard substance. The Redwood cup is of copper, silvered inside to prevent corrosion of the metal, 3½ in. (82.5 mm.) deep, and 1⅞ in. (46.8 mm.) internal diameter; the bottom of the cup is of stout copper and not jacketed; the jet is made of agate, the bore is 10 mm. long and 15 mm. wide; the measuring flask has a capacity of 50 cub. cm., and the standard substance is rapeseed oil of density 0.915 at 60 deg. F., 50 cub. cm. of which would require 535 seconds to enter the flask. When it takes t seconds to fill the flask, the Redwood viscosity is given by: $100\,t\,\delta/535\times0.915$, δ being the density of the oil at the testing temperature. The Engler cup is of brass, gilt or platinised inside, 106 m.m. in diameter, 32 mm. deep (between marks, the full depth is much greater); the jacket surrounds the whole cup; the jet passes through the jacket in a length of 20 mm. and tapers very slightly from 2.9 mm. to 2.8 mm., probably to facilitate trueing up with the aid of a reamer. The measuring flask has marks at 200 cub. cm. and again at 250 cub. cm.; the results are expressed in Engler degrees, and the standard substance is distilled water. When it takes t seconds to discharge 200 cub. cm. of an oil, then the Engler degrees are given by the quotient t/t_w, where t_w indicates the number of seconds (50) it takes to discharge the same volume of water at 20 deg. C. (68 deg. F.). The viscosity of water is assumed to be 0.01797 at 0 deg. C. According to L. Archbutt and R. M. Deeley, the viscosity of water is, at 70 deg. F., 0.01028, whilst T. E. Thorpe and J. W. Rodger found 0.010015. Thus the agreement as to the standard substance is hardly satisfactory even for water, which is easily purified, whilst as regards rapeseed oil it is doubtful whether even the best-refined oil has a viscosity of lasting constancy (Archbutt and Deeley).

The Saybolt viscosimeter has recently been modified. The universal Saybolt, as used in the tests to be mentioned, is a cylindrical cup, about 3 cm. diameter, height about 8 diameters, filled to the brim, the overflowing liquid being collected in a gallery; the cylinder ends below in a tube, 1.4 cm. long, 0.18 cm. bore, which is surrounded by a wider tube, longer than the jet, this wider tube being charged with compressed air and closed by a cork; to start the oil flow, the cork is withdrawn. The corks are apt to leak, but the errors of the Saybolt do not appear to be greater than with other types of instruments. The viscosities are expressed as in the Redwood instrument, but the standard substance is water; the measuring flask has a capacity of 60 cub. cm., and the reference temperature is 70 deg. F.

All these viscosimeters require very careful finish and handling, and the reduction of the values observed to c.g.s. units is not a matter of one simple formula. There is quite a literature, general and special, on the subject. We may in particular refer to the researches of Mr. W. F. Higgins "On Methods and Apparatus for Petroleum Testing" (National Physical Laboratory, Collected Researches [16 pages], 1913), and of Mr. Winslow H. Herschel, "On Determination of Absolute Viscosity of Short-Tube Viscosimeters" (Bureau of Standards, Technologic Paper No. 100 [55 pages]. November, 1917). Mr. Higgins dealt particularly with the Redwood and Engler viscosimeters, Mr. Herschel with those of Engler and Saybolt. The theoretical considerations affecting the problems are briefly these. The experiments of Poiseuille and others lead to the formula: $q = \pi\, p\, r^4 / 8\eta\, l$, where q is the volume of liquid discharged in unit time, p the difference of pressure of the liquid over a length l of a capillary tube of radius r, and η of the viscosity. The formula only holds for rectilinear flow, along stream-lines parallel to the axis of the tube, and for tubes of infinite length. In practice there is an end effect, which tends to make l greater by a quantity λ which is always positive; this λ is generally expressed in terms of the radius r, $\lambda = n\,r$, where n is the coefficient of correction. Higgins adopts $n = 1.64$ for the Redwood viscosimeter, Herschel finds $n = 1.3$ and 1.5 for two Engler, and 0.8 for the Saybolt instruments. The pressure at which the oil enters the jet tube is partly expended in setting the liquid in motion and not in overcoming viscous resistance; thus we have to distinguish between the pressure due to the head h in centimetres of the oil above the jet, given by $g\,\delta\,h$, where g is the gravity acceleration and δ the density of the oil expressed in grammes per cubic centimetre, and the kinetic energy term depending upon the velocity v in centimetres in the tube and a coefficient m. Boussinesq showed that $m = 1.12$; in practice $m = 1$ is mostly accepted. Herschel finds $m = 1.03$ for the Engler, and $m = 0.97$ for the Saybolt instruments, by determinations with varied rates of flow. As the discharge takes place under a decreasing head of liquid the average head is not easily determined, and the flow of liquid must not be allowed to become turbulent. According to Osborne Reynolds turbulence sets in for water when $2\,r\,v\,\delta/\eta$ (Reynolds' criterion) has the value 2,000 (approximately). It is mostly assumed that in technical short-tube viscosimeters the criterion is never exceeded; but the value holds only for long tubes, and Herschel finds that values of 1,750 and 1,500 should certainly not be exceeded, and that the formula for the kinematic viscosity η/δ does not apply strictly any longer for criterion values above 800. His formula for the kinematic viscosity is that of Couette, as modified at the Bureau of Standards by E. C. Bingham (1916): $\eta/\delta = \pi\, g\, r^4\, t\,(h - m\,v^2 g) / 8\,q\,(l + \lambda)$.

The temperature is a very important factor in viscosity determinations. The density of an oil does not change much with temperature; yet in eight oils which Higgins tested, among which were a shale oil (No. 1, the lightest), olive oil (No. 4), fuel oil (heaviest, No. 8), the density decreased from 0.8595 to 0.8200, from 0.9195 to 0.880, and from 0.956 to 0.917 (taking these oils Nos. 1, 4, 8) as the temperature was raised from 10 deg. to 70 deg. C. The corresponding viscosity changes were much greater, being 0.1075 to 0.0208 (No. 1), 1.38 to 0.124 (No. 4); the viscosity of the heaviest oil (No. 8), tested only between 25 deg. and 50 deg. C., fell from 5.15 to 1.00, all in c.g.s. units. The percentage change of viscosity per 1 deg. C. was 3.2 about 20 deg. C. and 2.6 about 65 deg. C. (No. 1) and 4.7 to 4.1 with a minimum of 3.2 at 40 deg. C. (No. 4); heavier oils decreased their viscosity by 7 per cent. per degree Centigrade in the neighbourhood of 20 deg. C., the change becoming smaller as higher temperatures were reached. The Redwood viscosity numbers (in the same order, Nos. 1, 4, 8) were 7.2, 44.3, 293, and the corresponding absolute viscosities 0.057, 0.540, 3.65—all at the temperature 30 deg. C. The general equation of Higgins connecting the viscosity η and the time of outflow t (in seconds) for the Redwood viscosimeter is $\eta = (0.0026\,t - 1.715/t)\delta$. In the case of the Engler instrument Higgins made use of the formula of Ubbelohde, which has since been modified; for No. 1 oil the ratio t_R/t_E of the values given by the two types of instruments rose from 1.84 to 1.86 as the temperature was raised from 10 deg. to 30 deg. C.; in these cases the time of flow on the R instrument ranged from 59 seconds to 41.5 seconds; for times of flow greater than 150 seconds the ratio t_R/t_E had the approximately constant value of 1.81.

In his absolute determinations Higgins availed himself of the method employed by Thorpe and Rodgers (1894) in their investigation of the relation between viscosity and chemical constitution. Two vertical tubes of internal diameter 2 cm., are joined by a horizontal capillary, 5 cm. in length; the upper end of either can be connected either to the atmosphere or to a reservoir of air under pressure, and the liquid in the tubes is forced by this air from one limb through the capillary into the other limb, the fall and rise of liquid being determined. The U-tube system is immersed in an electrically-heated water bath. The diameter of the capillary was determined both by the mercury-thread method and by measuring the electric resistance of the mercury filling the capillary. In determining the relation of kinematic viscosity to the time of flow of a technical viscosimeter, Higgins used the formula $\eta = (A\,t - B/t)\delta$, where δ is the density and A and B are constants depending upon dimensions; for this purpose the m and n above-mentioned must be known. When the equation is written $\eta/t\delta = A - B/t^2$, and the values of $y/t\delta$ are plotted as ordinates against the $1/t^2$ as abscissæ, the resulting curves are straight lines, from which the A and B can be read off. This method, as Herschel points out, dispenses with the need of accurately determining the dimensions of the viscosimeter, which would be difficult.

In his researches, Herschel applies the graphical method of Higgins and further that of E. Grüneisen (Reichsanstalt), who investigated the conditions under which Poiseuille's law held within definite limits of error, which he found to depend upon Reynold's criterion and the ratio of length to diameter of tube. Calling the apparent viscosity η^1 and the true viscosity η (from long tube experiments), his percentage error was $\left(\frac{\eta^1}{\eta} - 1\right)$ 100. Herschel now plots Reynold's criterion against the percentage error. When this curve is a straight line, m does not vary with velocity; but he finds that m does vary in the Saybolt and Engler instruments when the criterion value exceeds 1,500 and 1,750 respectively (as stated), and that water is, in fact, unsuitable as a standard substance for short-tube viscosimeters when the criterion may exceed the value 800. Thus the formulæ of Ubbelohde and Meissner would be unreliable. In the course of his experiments Herschel performed more than 500 tests (or 5000 runs) of the two kinds of instruments with water, olive oil, alcohols (ethyl and butyl) and with sugar solutions of different concentrations; the appendix to his paper contains tables of density, viscosity and fluidity (the reciprocal of viscosity) for temperature intervals of 10 deg. C. between 0. deg. and 100 deg. C. His final formulæ for the kinematic viscosities of the Saybolt and Engler viscosimeters are: $\eta/\delta = 0.00213\,t - 1.535/t$ (Saybolt), and $0.00147\,t - 3.74/t$ (Engler). Detailed instructions for the manifold precautions to be observed in using the viscosimeters are given in the paper, and following Holde and Ganz conversion factors were also determined by the aid of which determinations can be made in cases when there is not sufficient liquid at disposal to fill the cups completely. The whole question was to be discussed by the International Association for Testing Materials, and is perhaps best left till then.

THE NEW TROLLHÄTTA CANAL.

(*Continued from page* 627.)

The Dimensions of the Culverts.—The smallest cross-section of the culverts is such that the filling of a lock at the highest possible lift can be effected through two inlet channels in about 300 seconds, without disturbance of the vessels.

It was, however, impossible to determine theoretically the cross-section of the culverts, as reliable data, as far as is known, are not available for fixing some the factors concerned, as for instance the most desirable hoisting speed of the sluices and the permissible amount of wake movement arising in the upper basin. In order to arrive at an approximately correct determination of these factors a model lock, to the scale of 1 : 25, was constructed at Trollhättan. The dimensions of the culverts in this model were calculated approximately in the following manner :—

If the sluices could be suddenly opened, then the requisite aggregate opening area for both inlet channels would have to be

$$A = \frac{2\,Q}{\mu \,.\, T \,.\, \sqrt{2\,g\,h}}$$

Where

Q = the quantity of water to be let into the lock.
μ = the coefficient for frictional losses in the culverts.
T = the filling time.
g = acceleration due to gravity.
h = lift of lock.

Supposing

h = 8 m. (26 ft. 3 in.).
Q = 8 × 1,500 = 12,000 cubic. m.
μ = 0.7.
g = 9.81 m. per second, and
T = 300 seconds.

Then

$$A = \frac{2 \times 12{,}000}{0.7 \times 300 \times \sqrt{2 \times 9.81 \times 8}} = 9.14 \text{ sq. m.}$$

With this area the quantity of water flowing in at the first moment, per second, should be

$$q = \mu \,.\, A \,.\, \sqrt{2\,g\,h} = 0.7 \times 9.14 \times \sqrt{2 \times 9.81 \times 8} = 80 \text{ cub. m. per sec.}$$

It is quite evident that the sudden introduction of such a large quantity of water would cause a violent movement to a vessel lying in the lock. The opening of the sluice valves must, therefore, be done gradually. If the desired time of about 300 seconds for filling the lock is to be maintained, the cross-section of the culverts must, therefore, be increased beyond the figure arrived at above. By means of a series of trial calculations it has been ascertained that if, with a lift of about 8 m., the culvert cross-section is increased by about 25 per cent., or up to 11.5 sq. m. (124 sq. ft.), the desired rate of filling in 300 seconds can be achieved, even if the valves with a constant speed of opening occupied 2 to 2½ minutes in their travel. The inflow of the water could then be regulated so as to cause no disturbance. In the same way the requisite cross-section of culvert for the locks with a smaller lift, and for the intermediate culverts in the flight of locks, has been calculated at an aggregate cross-section of 9.5 m. (102 sq. ft.).

The lengthening of the time occupied in filling which results from hoisting the valves more slowly does not cause any special inconvenience, as the filling time does not increase in the same ratio as does the time occupied in opening the valves.

Supposing

T = time occupied in filling with gradual valve opening.
T_0 = time occupied in filling with instantaneous opening.
t_1 = valve-opening time.

Then

$$T = T_0 + \frac{t_1}{2}.$$

From the model tests undertaken at Trollhättan it has been ascertained that the inlet culvert areas found by this rough calculation are ample. It has thus been ascertained that if in the actual lock with a lift of 7.2 m. (corresponding with the—in the model lock—highest possible lift at the upper gate chamber) the sluice valves in the larger culverts are gradually opened during a period of 85 seconds, the lock is filled in about 235 seconds, and a vessel lying in the basin above the lock will be subject to a maximum drag of about 2 tons, which may be considered permissible. The corresponding time required for filling a lock with the smaller culverts may be calculated at about 290 seconds.

In locks with a greater lift than the one just mentioned it has likewise been ascertained by experiments that the stipulated filling time of 300 seconds can be maintained. Thus it has been proved by filling a lock connected to and located below the model lock referred to above, with a drop to begin with corresponding with 16.4 m., that the greatest impact against a vessel lying in the lock will be 2 tons, the time occupied in opening the valves being 150 seconds and the time of filling about 220 seconds.

As the model experiments have thus confirmed the suitability of the calculated dimensions of the culverts, the proportions have been fixed accordingly. The culverts, consequently, have been designed in two sizes, viz. :—

$$\text{Type I} = \frac{11.5}{2} = 5.75 \text{ sq. m. (62 sq. ft.)}$$

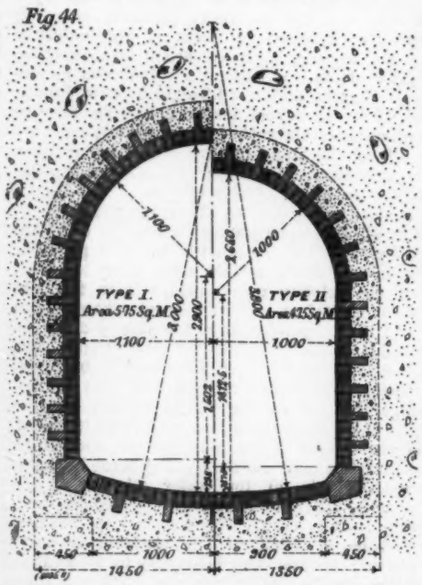
and

$$\text{Type II} = \frac{9.5}{2} = 4.75 \text{ sq. m. (51 sq. ft.).}$$

Type I is used at lock II, at the upper gate chamber in lock III, and the lower gate chamber in lock V, whilst type II has been adopted at lock I, the middle gate chambers in the flight of locks, and at lock VI.

The Shape of the Lateral Culverts.—The culverts have been given a cross-section (Fig. 44) which is nearly as efficient as the circular section, and at the same time is comparatively easy to construct. The two types of culverts have the following dimensions :—

Fig. 44.



	Height.	Breadth.	Radius of Arch at Top.	Radius of Invert.
	m.	m.	m.	m.
Type I ..	2.9 (114 in.)	2.2 (86 in.)	1.1 (43 in.)	3.0 (118 in.)
Type II ..	2.65 (104 in.)	2.0 (79 in.)	1.0 (39 in.)	3.8 (150 in.)

In the angle between the invert and each vertical side a granite skewback is inserted. These cross-sections are only used on the lengths in which the sluice valves are located. Beyond these the section is increased towards the ends of the culverts, as in the shorter inlet channels at the upper gate chambers of the single locks and in the intermediate gate chambers in the flight, by increasing the height or the breadth, or, in the case of the longer outlet channels at the lower gate chambers in the single locks, by adopting a full circular section with a diameter equal to the height of the normal section. The inlets to the culverts have rounded inlets to facilitate the entry of the water.

The position of the culverts was fixed in the following manner :—The section in which the valves are located is everywhere placed with the upper edge 0.1 m. beneath the lowest water-level occurring in the lock. This position, as was demonstrated at the model lock experiments, makes it possible to avoid all suction of air into the valve shaft when the water is being admitted. The position of the culverts is such that the inner edge in the junction to the outlet opening has a minimum radius in plan of 1.8 m. (70 in.), which the model experiments showed to be necessary to avoid a vacuum at that point of the culvert in question.

The inlet channels at lock II are both placed on the east side of the lock, and are supplied from a separate channel ; through this arrangement all motion of the water in the basin immediately above the lock is avoided on the opening of the sluices, so that vessels in the basin can lie perfectly still. The inlet channels do not in this instance open into a sump beneath the bottom of the gate chamber, but into a slot in the bottom of the lock immediately below the sill.

Further, at the outlet from lock V the culverts have been placed on one side, proceeding from the lower end of the bottom channel at the side of the lock and opening into an outlet channel to the river, located behind the masonry of the lock. This prevents the water from the lock flowing out into the basin immediately below. Wreckage guards are fixed in front of the upper culverts at lock I.

A water chamber runs, as already stated, underneath the whole of the lock chamber, with openings for letting the water through. These openings have been proportioned and spaced so as to ensure a nearly uniform influx of water over the whole of the bottom of the canal. To this end it was necessary to determine the hydraulic gradient from end to end of this chamber. From this the maximum upward pressure on the roof of the culvert was estimated as follows :—

1. *During Filling.*—On the water flowing into the lock a certain hydrostatic pressure exists in front of the inlet to the bottom channel, proportionate to the difference in pressure between the water-level above and in the lock, reduced by the loss of pressure due to the eddying in the culverts. There is a further loss of pressure in the bottom channel due to friction there and in the roof openings.

The quantity of water passing along the chamber continually decreases, on account of the water flowing out through the roof openings into the lock.

It was assumed that the quantity passing along a section at a distance x from the inlet to the culvert could be expressed as $Q = Q_0 - qx$. Since the water is at rest at the far end of the culvert $Q = 0$ at this point, so that $q = \frac{Q_0}{l}$, where l denotes the effective length of the chamber.

Let p denote the hydrostatic pressure at the section x and v the velocity there.

Then the sum of the pressure and velocity heads at this section is $\frac{p}{G} + \frac{v^2}{2g}$; where G denotes the weight of unit volume of water.

At a section a little later on, at x_1 say, the corresponding heads will be $\frac{p_1}{G} + \frac{v_1^2}{2g}$.

If f denote the head wasted in friction between x and x_1 we get :

$$\frac{p}{G} + \frac{v^2}{2g} = \frac{p_1}{G} + \frac{v_1^2}{2g} + f.$$

Let $\overline{v}$ denote the mean velocity of the flow between the two sections in question. Then $f = k \cdot \frac{\overline{v}^2}{2g}(x_1 - x)$ where k is a constant depending on the hydraulic mean depth of the channel and on the roughness of its surface.

At the limit when $x_1 - x = dx$ we get

$$\frac{1}{G}\frac{dp}{dx} + \frac{1}{2g} \cdot \frac{d(v^2)}{dx} + k\frac{v^2}{2g} = 0.$$

Now if Ω be the area of the channel, $v = \frac{Q}{\Omega}$ and since $Q = Q_0\left(1 - \frac{x}{l}\right)$ we get

$$\frac{1}{G}\frac{dp}{dx} - \frac{Q_0^2}{2\,\Omega g^2}\left(1 - \frac{x}{l}\right) \cdot \frac{x}{l} + \frac{k}{\Omega^2}\frac{Q_0^2}{l\,g} \cdot \left(1 - \frac{x}{l}\right)^2$$

On integration this gives:

$$\frac{p}{G} = \frac{Q_0^2}{Q^2} \cdot \frac{1}{2g} \cdot \left[\left[\frac{x^2}{2l} - \frac{x^3}{3l^2}\right] - h\left(x - \frac{x^2}{l} + \frac{x^3}{3l^2}\right)\right] + C$$

where C is the constant of integration determined by the value of p when $x = 0$.

In the present case it was assumed that the maximum velocity of flow at the entrance of the culvert was not to exceed 4 metres (13 ft.) per second). On this assumption the value of p_0 is easily found by deducting from the total head the frictional losses in the waterways up to this point.

With the hydraulic gradient thus determined the dimensions of the openings from the bottom chamber into the lock were easily fixed so as to give a practically uniform inflow along the whole of the bottom of the lock. From the model experiments it was found that the coefficient of discharge for these openings could be taken as 0.85, and the dimensions were fixed so that the maximum speed through them did not exceed 2 metres (6.56 ft.) per second.

By a similar course of reasoning, the hydraulic gradient along the chamber was determined during the emptying of the lock. Knowing the hydraulic gradients both on filling and emptying the lock it was, of course, a simple matter to determine the greatest upward thrust on the roof in the first case and the greatest downward pressure imposed on it in the other case.

Bottom Chamber for Lock I.—For lock I the bottom chamber details have been calculated in the following manner:—

1. *Pressure curves for calculating the strength of the construction.*—(*a*) At the filling of the lock the valves are supposed to be lifted in the shortest possible time, which at lock I is 15 seconds. The greatest head available before the lifting of the valves is 6.3 m. (20.6 ft.). When the sluice valves are lifted the effective decreases as the inflowing volume of water increases. A calculation of the head at which the largest volume of water flows through the valves has been carried out in the following manner:—

Assume that

The head before lifting the valves ...	= H
The horizontal area of the lock chamber	= F
The aggregate valve area of the inlet channels	= A
The aggregate valve area of the inlet after t seconds	= a
Rise of water in lock after t seconds ...	= h
Total time occupied in opening	= T

the effective head after t seconds will be $= H - h$.

During a time-element dt, at time t, a volume of water will have flowed into the lock

$$dt \cdot \mu \cdot a \sqrt{2g(H-h)} = F \cdot dh$$

Suppose the valves are lifted with a constant speed, so that the effective area of the inlet channels increases proportionally with the time, then

$$\frac{a}{t} = \frac{A}{T}$$

If this value of a is inserted in (1), then after integration

$$\frac{t^2}{2} = \frac{2F \cdot T}{\mu \cdot A \cdot \sqrt{2g}} \left(\sqrt{H} - \sqrt{H-h}\right)$$

In the present case

H	= 6.3 m.
μ	= 0.8 (probable value, according to model experiments).
A	= 9.5 cub. m.
P	= 1,500 cub. m.
T	= 15 seconds.

By inserting these values in the equation and different values for t from 0 to 15 the corresponding values for h were obtained, which were plotted as ordinates for the curve represented in Fig. 45 by the full line. The vertical distance between this curve and the upper horizontal line shows the variation of the effective head during the lifting of the valves.

The quantity of water entering through the valve openings amounts in each moment to

$$Q = \mu \cdot a \cdot \sqrt{2gh}$$

Taking the values of the effective head from the curve just referred to, and the uniformly increasing values of a from 0 to 9.5 sq. m. during 15 seconds, the successive values of Q are calculated and are shown by the dotted line in the same figure.

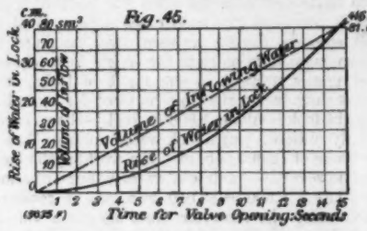
It will appear from this line that the inflowing quantity of water is largest when the valves are fully lifted, and the inflowing volume of water will then amount to Q = 81.6 cub. m. per second. The corresponding pressure difference at this time is 5.88 m (19.28 ft.).

The waterway has been dimensioned so that the speed, at the largest inflow of water, shall not exceed 4 m. (13 ft.) per second. With due regard to this the cross-section A has been made 20.2 sq. m. (215 sq. ft.).

The quantity of water flowing out of the bottom chamber per metre run is then $q = \frac{Q}{79.5} = 1.03$ cub. m. (36.3 ft.) per second.

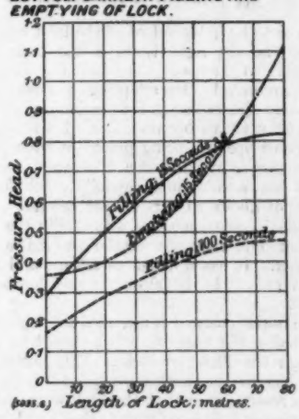
With a view to accidental surges and variations in the water pressure, the calculated values for p have been increased by 10 per cent., being shown in Fig. 46 as ordinates with the values of x abscisse to a

Fig. 45.



Drop from Commencement 6.80m

Fig. 46. CURVES OF PRESSURE IN BOTTOM CANAL AT FILLING AND EMPTYING OF LOCK.



curve, represented by a full line in the figure. As will appear from this curve, the pressure on the roof of the bottom chamber is greatest at the lower end, where it amounts to 0.822 ton per sq. m. (171 lb. per sq. ft.). The values thus calculated harmonise well with those obtained in the model experiments.

(*b*) *During the emptying of the lock.*—Proceeding in a similar way for the calculation of the pressure during the emptying of the lock, the chain dotted curve shown in Fig. 46 is obtained, which expresses the downward pressure on the roof of the bottom chamber. As before, these computed pressures were in good agreement with model experiments.

As will appear from both curves, the pressure in the bottom chamber on the upper 60 m. (excepting the 6 m. nearest the inlet) is greater in filling the lock than in emptying it, whilst below that distance the pressure is greater at emptying. The strength of the roof was computed for the highest pressure occurring at each section.

2. *Pressure curve for calculating the dimensions of the roof openings.*—The roof openings are so dimensioned that on filling the lock an evenly distributed outflow takes place over the whole bottom of the lock, when the valves are raised at the intended rate of opening. During emptying this uniformity of flow is unnecessary, as the risk to a vessel in the lock then is considerably smaller than during filling. In any case it is not feasible to construct the roof openings of such dimensions that they shall ensure an equable flow during both filling and emptying.

From the model experiments a valve-opening time of 100 seconds could, it appeared, be considered satisfactory for lock I. The effective head at which the largest quantity of water runs through the valves is, taking T as 100 seconds, 3.8 m., the rate of inflow is then 65.6 cub. m. The inflowing volume of water thereby amounts to 65.6 cub. m. per second. On this basis the value of the pressure along the whole bottom chamber was computed. Adopting a series of different values for p, the requisite effective inlet area of the roof openings was computed.

The Construction of the Bottom Chambers.—In order to determine the most economical method of forming the bottom chamber comparative calculations as to cost were made, in the one case for reinforced concrete and in the second for a roof of steelwork and wood. Of the latter construction several types were examined, viz., with longitudinal or cross support girders and with one, two and three support columns in the breadth.

The cheapest construction for lock I, and which is also looked upon as sufficiently durable, was found to consist of iron girders supported on three columns, and with a roof of wooden beams transverse to the axis of the lock, as shown in the illustrations (Figs. 32 to 41, Plate LVI *ante*).

The girders are Differdinger beams N. 24, stayed together at intervals by angle irons. On the lower flanges of these girders rest the wooden beams forming the roof. The supporting columns have to take both compression and tension, and consist of cast-iron pipes filled with concrete in which are embedded iron rods which are securely anchored in the rock bottom of the chamber. The cast iron is only intended as a protection to the concrete, and is not relied on to take any of the down thrust, which is transmitted to the concrete by means of a cast-iron plate bolted to the steel beam above. The anchoring bolts, by which the upward pull is transmitted, go through both flanges of the Differdinger beams and are tightened by means of nuts on the upper side of the beam.

The openings are made by omitting the wooden beams at certain distances. The roof openings vary in size, being largest at the upper end of the lock and with decreasing dimensions towards the lower end of the lock. The greatest breadth of the openings is 380 mm., the smallest 100 mm. The wooden beams round the openings are rounded off, and as an experiment some of the beams here are covered with 2 mm. of galvanised plate. These wooden beams are kept in position by means of wedges underneath the upper flanges of the Differdinger girders.

The Reservoir at Aker.—In fixing the permissible limits for the water-level variations in the reservoir, it had to be considered that the old locks to and from the reservoir in the meantime must continue to be used for traffic, and that the local conditions for the construction of the locks and the reservoir should be utilised to best advantage. With regard to the existing locks, the water-level in the reservoir could not be lowered beneath the present low-water level of + 29.54. On the other hand, so as to reduce the work for the locks and the reservoir as much as possible, and in view of the relatively large variations between high and low water level in the reservoir, it was found that the low-water level could not be very well raised above + 30.0. Accordingly this level was accepted as the lower limit of the water-level. The high-water level in the reservoir, on account of local conditions, was limited to + 31.9. On account of the small area of the reservoir, its water level very much affects the water flow through the locks, wherefore it was found necessary to adopt special arrangements for regulating this water-level.

The arrangements required for this purpose depend upon the traffic through the locks, and in this connection the following traffic combinations had to be considered:—

1. Repeated passages down the locks only.
2. Repeated passages up the locks only.
3. Simultaneous passages down the single lock and up the flight of locks.
4. Simultaneous passages down the single lock and up the single lock and down the flight of locks.

In case 1 a volume of water equal to the volume

of water of the single lock flows into the reservoir at each discharge. With a series of passages down the flight of locks, if the locks are supposed to be of the same size, a volume of water is required equal to the water volume of the flight of locks. If the locks of the flight had the same volume as the single lock, it would not be necessary to provide for more than one single lock-volume of water in the reservoir at the time. The volume of the single lock, however, on account of its greater lift, is larger than that of the flight locks. As a consequence a volume of water remains in the reservoir at each passage through the single lock equal to the difference between the lock-water quantities of the single lock and the flight of locks.

In case 2 a volume of water is transferred for each passage up the flight equal to the sum of the lock water volumes of the three locks.

This quantity of water need only be taken from the reservoir for the first vessel which passes the flight upward, immediately after a passage down the flight has taken place. In such cases there is low water in all the locks of the flight, and the requisite three lock-water volumes must be taken from the reservoir. For the following upward-moving vessels the matter is different. Then all the locks of the flight are filled, so that the lowest lock-water volume is let out into the river, and each of the two upper ones, as the vessel passes upward, is tapped successively to the lock immediately below. As the upper lock is thereby tapped into the one below, it must be filled again from the reservoir. The total supply of water to the flight in such case consequently consists of only one lock-water volume.

If such repeated passages take place, as many lock-water volumes of the flight locks' dimensions are taken from the reservoir as water volumes of the single lock dimensions are led into the reservoir. If both these were equal it would never be necessary to collect more than one lock-water volume at the time in the reservoir. But, as already mentioned, the volume of the single lock is larger than that of the flight locks. Hence at each passage through the single lock a water volume will remain equal to the difference between the lock-water volumes of the single lock and the locks of the flight.

In case 3, that is, simultaneous passages down the single lock and up the flight of locks, matters are as follows:—Suppose a vessel has passed both the flight of locks and the single lock upward bound, so that all locks are filled, and that a downward-bound vessel enters the single lock simultaneously with an upward-bound vessel entering the bottom lock in the flight. The bottom lock of the flight is then ready to receive lock water some 200 seconds after the entrance of the vessel has commenced, but it obtains the requisite lock water from the lock immediately above. This latter lock is in a similar position when the vessel gets thus far, receiving the water from the lock above, the top lock. It is only when the vessel has got into the last-mentioned lock that it becomes necessary to draw from the reservoir for water. This takes place after the lapse of about 1,500 seconds from the start. During this time two passages through the single lock can be effected into the reservoir, which may thus receive two lock-water volumes before any water need be taken out through the flight locks.

In case 4, with passages up the single lock and down the flight, the latter locks receive water as often as water passes out from the single lock. In such cases it is consequently not necessary to collect more than one lock-water volume in the reservoir at the time. The largest quantity of water which could be collected simultaneously in the reservoir, if no extra outlet were provided, would thus be two lock-water volumes of the single lock dimensions, and this may happen with simultaneous passages down the single lock and up the flight of locks.

As the lock-water volume of the single lock on an average is $= 8.0 \times 1{,}500 = 12{,}000$ cub. m., and the reservoir has a surface area of about 22,000 sq. m., its water-level, by two lock-water volumes being let in, will rise

$$\frac{2 \times 12{,}000}{22{,}000.} = \text{about } 1.1 \text{ m.}$$

The water-level of the reservoir would thus rise to level + 31.1.

As will appear from the above, the flight of locks, under certain traffic combinations, would consequently be unable to dispose of all the lock water emanating from the single lock, producing a rise of level. On the other hand there may be cases when sufficient water cannot be supplied to the reservoir through the single lock for the requirements of the flight locks. For this reason it has been found necessary to construct both an inlet and an outlet to the reservoir for the sake of regulating its water-level. The inlet canal dimensions are so fixed as to enable it to supply the necessary amount of water to the flight locks when the single lock is unable to supply any water for the reservoir.

The time for a vessel's passage up the flight of locks, during which the lock water should be delivered from the reservoir, amounts to about 1,800 seconds. The longest interval between two tappings of the single lock happens when the traffic direction there is reversed. In such cases a time of about 1,350 seconds passes between two tappings. If such passages take place in the single lock whilst a vessel passes upward in the flight of locks, it is evident that during the time required for ascending the flight locks—about 1,800 seconds—the reservoir can only obtain a single lock-water volume, that is, an average of 12,000 cub. m. For working the flight locks, however, a maximum water volume of about $(30 - 6.3) \times 1{,}500 = 35{,}550$ cub. m. is required. Consequently the reservoir must supply a volume of $35{,}550 - 12{,}000 = 23{,}550$ cub. m. during a time of about 1,800 seconds, which amounts to

$$\frac{23{,}550}{1{,}800} = \text{about 13 cub. m. per second.}$$

So as to be independent of the inlet conduit being opened at the right time, it has been found expedient to increase its capacity beyond that thus computed. By adopting a closing valve of the same dimensions as the smaller one at the locks, that is, with an opening area of 4.75 sq. m., and the valve opening being placed at such depth that air suction is avoided, the inlet canal conduit provided has a minimum capacity, with fully raised valve, of about 27 cub. m. per second. This inlet conduit is constructed as a tunnel in the rock, east of lock II, with the intake at the upper gate chamber. It has a height of 2.5 m. and a breadth of 3.5 m., with the closing valve located at the intake.

The outlet channel is intended to dispose of water collected in the reservoir which cannot be tapped-off through the flight of locks. This outlet arrangement has to automatically regulate the water-level in the reservoir, so that the high-water level never rises above + 31.0. On the other hand, the crown of the outlet must be placed so high that a quantity of water can be stored in the reservoir large enough for the filling of the upper lock of the flight without lowering the low-water level below + 30.0. The portion of the outlet channel nearest the reservoir has the same dimensions as the intake.

(To be continued.)

WERKSPOOR DIESEL MARINE ENGINES.

(Concluded from page 635.)

In addition to engines of the types illustrated in our issue of June 7, the Nederlandsche Fabriek van Werktuigen en Spoorwegmaterieel of Amsterdam, commonly known as the Werkspoor, some time ago contracted for the building of twin engines for a small vessel to run at a speed of 14 knots. The conditions called for 1,200 brake horse-power at 300 r.p.m., with a total weight of the two main motors, including flywheels, under 33 tons. Generally, two-cycle motors, with their necessary complication, would have been adopted, but the Werkspoor succeeded, while following in great measure their standard design, in keeping within the same limits of weight or nearly so. The cross-heads, however, had to be abandoned, and the general construction of internal-combustion cylinders and connecting rod adopted, as will be seen by the illustrations on Plate LVIII and on the opposite page.

In order to save weight and space the two engines are inclined to each other (Figs. 9 and 15). The cylinders are carried in a beam, as already described, and the two beams have each a flange (Fig. 9) by which they are united. The bedplates are also connected at each main bearing by light steel castings, and there is no framing other than the steel rods mentioned in our former article, and clearly shown in Fig. 10 and in Figs. 12 to 14. The arrangement makes a very stiff structure.

Although all parts are of a light and simple construction, no vibration, we are informed, is perceptible, even when the engines are running at full speed. As a consequence of this type of construction it became possible to omit the parts of the bedplate between the bearings. Apart from the saving in weight so obtained, the crankshafts thus become very accessible, which is an important advantage. Of course, greater care had to be bestowed on the placing of the propeller shafts than is generally the case.

The motors have forced lubrication; they are made oiltight by light steel plates at the sides, as well as in the bottom. This style of construction leads to lightness and accessibility. The fuel supply is provided, as it is usual with the Werkspoor Diesel engines, by a single pump, which pumps the fuel into a vessel where the same air pressure exists as in the valve cages. The air compressor which injects the charge is shown to a larger scale in Fig. 11.

The dismounting of the pistons is effected as explained in our previous article, the lower parts of the cylinders being detachable. This plan has been patented by the Werkspoor. It must be noted, however, that the removable ends of the cylinders shown on Figs. 12 to 14 were only used by way of trial and were later replaced by castings of cylindrical form as represented in the drawings, not cut away at the sides.

The camshafts of each motor are driven from the crankshaft by four connecting rods and an intermediate shaft running at half-speed, the customary Werkspoor design. There are two camshafts, one for running ahead, the other for running astern; they can be shifted sideways, so that either one or the other comes under the rollers of the levers that work the valves. By a handle, with gearing, one person can quickly accomplish this operation and is able to reverse the whole engine in a few seconds.

The crankshafts, made by Krupp, are of manganese nickel-steel of high tensional strength. This material proved to be too hard, for after being in service for about six months the crankshafts developed large cracks in several places, so that new ones had to be put in. This time material of lower tensional strength was chosen and the central bore of the shaft was made smaller.

Except for this mishap these engines have been running well. All working parts are very easily accessible, so that even for replacing the crankshafts only the outer steel stays and the connecting rods have, to be dismounted. At all speeds the engines run without vibration, thanks to the stiffness of the entire construction.

BLAST-FURNACE BEARS.*

By Dr. J. E. Stead, F.R.S., Vice-President.

A bear, sometimes called an old horse, a sow or salamander, is the blast-furnaceman's term for the mass of metal which is found below the hearth level of a blast furnace after the furnace has been blown out.

During the working life of blast furnaces the base or bottom linings are more or less fluxed away and replaced by metal, which, being below the tapping hole, cannot be run out of the furnace. In the course of time the metal gradually works its way downwards for a distance of 3 ft. to 12 ft or more, and, as it cannot be removed in the liquid state, it solidifies into masses which may weigh anything between 50 tons to 800 tons.

Some furnaces which have been at work for twenty to thirty-eight years, during their lifetime have had a checkered experience owing to strikes and stoppages from other causes, varied temperatures in the hearth due to irregularity in the working, and other conditions. It is evident, therefore, that the metal, originally completely fluid, would at such times pass more or less into the semi-solid condition and become totally solid after long-continued stoppages. After the reservoir of metal has cooled down and solidified during temporary stoppage, and the furnace is again put on blast, the metal will gradually become molten, but before it is all remelted there must inevitably be fluctuations in the hearth temperature, consequent checking of the melting process, and probably a resolidification of portions of the remelted metal.

When the bear is finally quite cold, after the furnace is blown out, it may have impressed upon it characteristics the result of all these variations, whatever they may be.

One might at this point discuss the question as to how to build furnace hearths which would resist the attack of the metal, but beyond suggesting that magnesite bricks appear to give the greatest promise, it is not proposed to deal further with the question here.

Variable Character of Bears.

The immense blocks of solid metal are usually broken up bit by bit by drilling and blasting, and the interior structure or character is then readily seen. In all, the

* Paper taken as read at the meeting of the Iron and Steel Institute on May 3, 1918.

1,200-B.H.P. TWIN DIESEL MARINE ENGINES.

CONSTRUCTED BY THE NEDERLANDSCHE FABRIEK VAN WERKTUIGEN EN SPOORWEGMATERIEEL, AMSTERDAM.

(*For Description, see opposite Page.*)

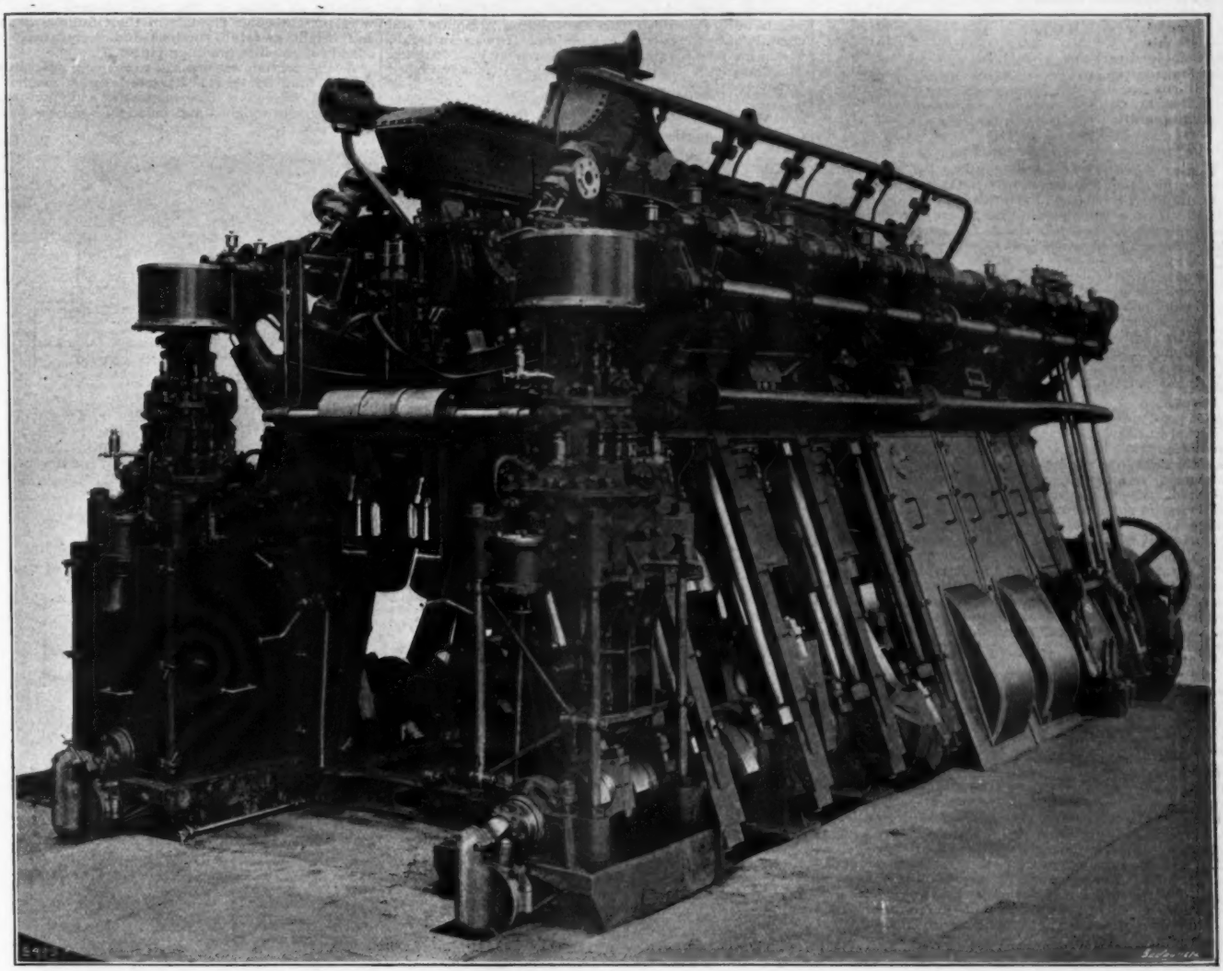


FIG 15.

feature which first strikes the observer is the presence of considerable quantities of what appears to be kish or graphite, also grey metal of very open fracture, which has broken along the cleavages of large plates of graphite, and metal of all degrees of greyness progressively from the very open to the very close and on to the mottled and white. Very often one meets with conglomerates of kish, metal, and partly fused brickwork through which pass veins of a metallic substance. Sometimes specimens are met with which have the same colour as copper, and are rich in what has been called and described as nitrocyanide of titanium. But since the adoption of higher furnaces and greater blast pressure it is rare to find large accumulations of this, but it is always present in disseminated crystals in all furnace bears. In some bears one finds the nitrocyanide associated with dark blue idiomorphic crystals quite insoluble in even strong hydrochloric acid, and the fracture of the conglomerate has a blue cast. In the cavity of one bear from the hearth of a furnace which had been making ferro-manganese, large idiomorphic crystals of double carbide and silicide of manganese and iron were discovered by Mr. Poulaine.

In more than one bear a considerable quantity of carbonless iron rich in phosphorus was discovered.

In another bear a quantity of a substance closely resembling mill cinder was observed.

In many bears the lower central axes have a columnar structure almost identical with the basaltic formation of Staffa and the Giant's Causeway, but, of course the columns are relatively much shorter and of less diameter, the actual lengths varying from a few inches to more than a foot, and the diameters from $\frac{1}{2}$ in. to $\frac{1}{4}$ in.

One authority claims that he had found diamonds in a German bear, but they have not, so far as is known, been discovered in English bears.

Crystals analogous to rhabdite have been found, and conglomerates containing up to 66 per cent. of almost pure manganese sulphide and mixed sulphides of manganese and iron. All these substances will be discussed in the following order :—

1. Kish or graphite.
2. Graphitic metal with open and close fractures.
3. Sulphides of manganese and iron.
4. Cyano-nitrite of iron in red crystals.
5. Titanium di-cyanide in blue crystals.
6. Masses of oxides and silicates of iron.
7. Decarburised metal.
8. Columnar formation of metal, more or less completely dephosphorised.
9. Crystals of iron phosphide and iron carbide, from cavity in a bear. With a report thereon by Mr. L. J. Spencer, M.A., F.G.S., of the British Museum.
10. Carbo-silicide of iron and manganese. With a report thereon by Mr. L. J. Spencer, M.A., F.G.S.
11. Unique specimens for the microscopist.

Summary of main points of interest.

In the following remarks evidence of the existence of nearly all the above constituents will be advanced, together with hypotheses explaining as far as possible their genesis.

SECTION I.

Kish or Graphite.—It is well known that when very rich graphitic iron is running from a blast furnace, free graphite separates from the iron and floats to the surface, and may be blown away by wind or may rest on the surface of the solid pigs. No separation occurs so long as the temperature is at the maximum, but separation begins with falling temperature. It follows, then, that if a great mass of very grey iron in a ladle, or in the hearth of a blast furnace, cools down ever so little, graphite will separate. One knows that this occurs in ladles of fluid iron weighing 10 tons to 50 tons, for in a very little time after casting, graphite floats up and accumulates on the surface. The same thing most certainly occurs in the hearth of a blast furnace, for radiation from the sides of the well cools the metal, and some of the graphite will float upwards to be eventually burnt by the air blown into the furnace. When making ferro-silicon containing 10 per cent. and 15 per cent. silicon in a blast furnace the amount of coke required is high, as also is the temperature in the furnace, and as silicon always has the effect of liberating graphite as the metal cools, the radiation of heat from the sides of the well first of all affects the fluid metal in contact with the brickwork, graphite falls out of solution, adheres to the sides of the well, and continues to do so till a very thick layer is formed and the hearth is greatly reduced in capacity. When the accumulation reaches a certain point the capacity of the well becomes so reduced that it is impracticable to carry on the production of such graphite-forming metal and the furnace has to be changed to hematite, which dissolves away the graphite. In the manufacture of ferro-manganese, although the metal itself when cold is free from graphite, when in the fluid state it percolates between the bricks of the bottom of the furnace, the manganese reacts on the silica of the bricks, reducing it to silicon, and this, entering the fluid iron, throws out of solution a part of the carbon, which then separates as graphite, much of which is trapped and is prevented from rising to the surface of the metal.

Solid graphite, once it is adhering to anything that prevents it rising, has an attraction for more graphite in metal ready to part with it, so that in course of time there are considerable accumulations, mixed of course with entangled particles of metal, &c. The action of manganese is very severe on silica material—so much so, that it is impossible to keep melted ferro-manganese in a clay crucible without perforation. Obviously magnesia, as a hearth lining for furnaces making ferro-manganese, should be an advantage, for manganese has no action on that substance.

Graphite accumulations are, however, common in the

bears of all furnaces which have been used for making grey iron and even basic, mottled, and white irons, but it is always associated with entangled particles of iron and sometimes with slag and siliceous matter.

Mr. Greville Jones kindly supplied the author with an analysis of such a graphitic mixture, taken from the hearth of a blast furnace after making hematite pig-iron for five years at the Rhymney Iron and Steel Works, which is as follows, namely :—

	Per Cent.
Iron	69·99
Graphite	25·32
Combined carbon	1·20
Manganese	0·80
Silicon	1·85
Titanium	0·42
Phosphorus	0·03
	99·61

A similar deposit sent to the author by Mr. George Ainsworth, general manager of the Consett Iron Company, Limited, consisted of stratified layers of graphitic material between which were thin layers of a yellowish-green substance, evidently slag. An analysis made in Middlesbrough is shown below :—

	Per Cent.
Iron	18·30
Graphite	48·35
Combined carbon	trace
Manganese	0·675
Silicon and silica	6·76
Sulphur...	0·47
Phosphorus	0·019
Alumina, lime, &c.	25·426
	100·000

The stratification in layers is explained on the assumption that it was only on alternate occasions, when the fluid iron was extra grey, that graphite fell out of solution, and between these occasions that slag was deposited. The high sulphur present probably was mainly in the slag and not in the metallic portion.

Time is an important factor in facilitating complete separation of graphite, and wh[ere] large masses of grey iron in the fluid bears of almo[st] all blast furnaces cool down slowly, as they always do after the furnace is blown out, this condition for its separation is always obtained. Mr. Alfred Cochrane kindly supplied the author with a graphitic conglomerate from the hearth of No. 3 furnace of Ormesby Ironworks which had the following analysis :—

	Per Cent.
Iron	41·6
Graphite	39·4
Slag, &c.	19·0
	100·0

SECTION II.

Metal with Open and Close Fractures.—The open character of cast-iron depends on well-known conditions :—

1. As a rule, the greater the mass of solid grey iron, the larger are the crystals of graphite and coarseness of the crystalline fractures.

2. The more slowly grey iron solidifies the more open the fracture. A very small pool of Cleveland iron cooled down inside a mass of molten slag may have a fracture with cleavage faces a ¼ in. to ½ in. in area, while the same pool cooled in sand in the air will have a very close fracture.

3. Sulphur melted with open cast-iron has an influence in making the iron finely crystalline.

4. Low silicon under 0·5 per cent., when the carbon does not exceed 3½ per cent., is favourable to the production of white iron if cast in sand ; but the same iron, provided the sulphur is not excessive, if cooled very slowly, may be obtained with a quite grey fracture.

5. White and mottled iron, if remelted and cooled very slowly, may, and are likely to, have grey fractures more or less open in character.

In the case of bears from blast furnaces making mottled and white basic iron, the graphite separates out probably after the metal has become quite solid, and appears, not as flakes or curved plates, but in more or less spheroidal aggregations. This was well shown in a columnar mass of metal from the hearth of a blast furnace at Wigan, kindly presented to the author by Mr. F. M. Percy, a section of which was polished and etched at Middlesbrough. This was photographed, and is reproduced in photographs 2 and 3. No. 2 is the section magnified five diameters, No. 3 that of one of the rounded particles of graphite, the appearance of which suggests that it is built up of adhering fine plates of the same substance. The iron produced at this furnace, when cast into pigs, had a white or mottled fracture.

It follows from these premises, that almost all irons whether grey, mottled, or even white, if cast in sand, would, if cooled in the bears of blast furnaces, be grey and of more or less open fracture. Some portions of these bears have graphite cleavage faces varying from $\frac{1}{100}$ in. up to above 1 in. diameter, but generally are large.

SECTION III.

Sulphides of Manganese and Iron.—It is well known that when fluid raw iron contains manganese and sulphur, in cooling slightly, as it does in a mixer, in a ladle of metal, or in a large casting, the manganese sulphide floats upwards towards the surface and, if the surface layers are fluid escapes and forms a separate layer on the top of the metal. If the upper layers are solid the sulphide accumulates below the frozen metal, so that portions taken from the places where segregation has occurred may contain as much as 1 per cent. sulphur (= 2·7 per cent. MnS), although the average in the whole casting may not exceed 0·05 per cent.

In large masses of metal such as are found in bears it is not surprising to find segregations very rich in sulphide of manganese. In a bear from one of the Cleveland furnaces of Messrs. Bolckow, Vaughan and Co., Limited, kindly supplied to the author by Mr. D. Sillars, there was a marked instance of this.

The specimen had a bluish fracture, and the microscope revealed a ground mass of dove-coloured sulphide in which were embedded particles of iron, graphite, and crystals of cyano-nitride of titanium. It was crushed to the finest powder and the iron separated by a magnet. The magnetic and non-magnetic portions weighed respectively :—

	Per Cent.
Magnetic	28·0
Non-magnetic	72·0
	100·0

The magnetic part contained all the free iron and some embedded titanium cyanide. The non-magnetic portion contained about 4 per cent. of the non-magnetic titanium cyanide and 3·5 per cent. graphite, both of which, of course, were quite insoluble in hydrochloric acid. The soluble sulphides contained :—

	Per Cent.
Manganese sulphide	92·7
Iron sulphide	7·3
	100·0

The sulphides in the polished section appeared to be perfectly homogeneous, and it may be concluded that the sulphides of manganese and iron crystallised together and were in mutual solid solution.

In another portion of a bear from No. 4 Ormesby blast-furnace hearth the microscope revealed the dove-coloured sulphide, bright particles of iron, graphite and titanium cyanide.

After crushing to the finest powder and separating the iron by a magnet and the sulphides by acid the dissolved sulphides were found to contain :—

	Per Cent.
Manganese sulphide	80·1
Iron sulphide	19·9
	100·00

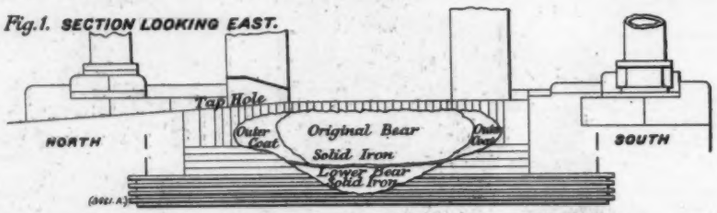
The mixed sulphides in the polished specimen in this as in the last case, were homogeneous.

A portion of a third bear kindly sent to the author by Mr. Alfred Cochrane came from the hearth of No. 3 Ormesby furnace, blown out after twenty-four years service. It is unique, as it contained about two-thirds of its mass of almost pure manganese sulphide. This specimen was readily sawn and drilled. The microscope revealed a matrix of what appeared to be quite homogeneous sulphides of the dove coloured type. There were present cubic crystals of the titanium compound, and bright metallic portions and segregated rounded islands of graphite (photograph No. 1).

A large portion was crushed to coarse powder in a steel mortar and the parts attracted by a magnet were removed from it. The magnetic and non-magnetic portions were weighed and found to be in the following proportions :—

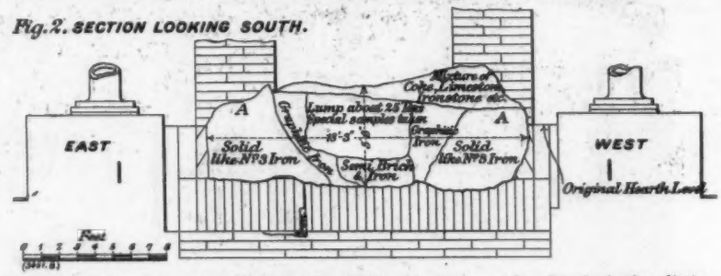
	Per Cent.
Non-magnetic	67·0
Magnetic	33·0
	100·0

Fig.1. SECTION LOOKING EAST.



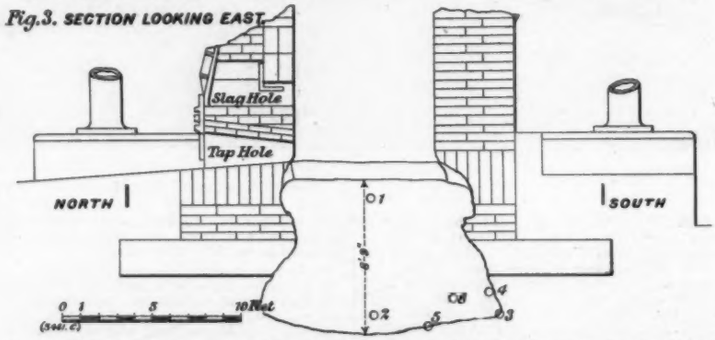
Furnace blown in May 8, 1876; blown out May 30, 1914. Total iron made 1,365,465 tons. Total weight of bear 263 tons, of which 162 tons 2 cwt. was clean metal. Between original and lower bears there was a layer of burnt firebrick varying between ¼ in. and 3 in. in thickness.

Fig.2. SECTION LOOKING SOUTH.



No. 3 furnace bear, as removed July–October, 1917. The bear was found to be in five distinct and separate formations :—Two central lumps with two annular masses round them and a top layer of partly reduced material.

Fig.3. SECTION LOOKING EAST.



Ormesby No. 4 furnace, removed November, 1914, to April, 1918. Blown in January, 1880; blown out July, 1886.

On examining the particles of the non-metallic powder each of them showed well marked cleavage faces.

The magnetic separation was not very perfect, for some particles of sulphide adhered to the metallic part. The chemical analyses are as follow :—

	Non magnetic. Per Cent.	Magnetic. Per Cent.
Iron	0·900	81·373
Manganese	59·390	4·532
Sulphur	35·181	2·321
Silicon	nil	2·410
Phosphorus	trace	0·945
Combined carbon ...	0·096	0·450
Graphite	2·822	1·759
Titanium	1·400	5·500
Nitrogen	0·200	0·710
Specific gravity ...	3·69	6·95

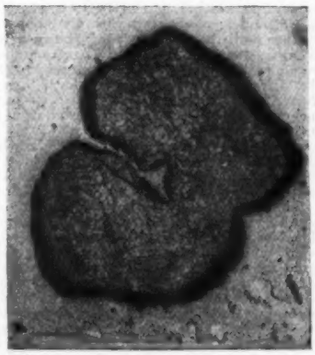
So far as could be ascertained, the titanium compound in this was of the same substance as that already described. The crystals were for the most part bedded in the particles of iron, as was proved by the analyses. As it was not magnetic, the particles of the cyanide which had separated from the iron in crushing the sample were found in the non-magnetic part. The

graphite must, of course, have been derived from the iron. The separated parts being in the ratio of two magnetic to one non-magnetic, it was easy to calculate the ultimate composition of the specimen, which was as follows :—

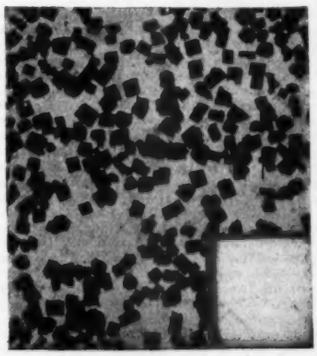
	Per Cent.
Iron	27·724
Manganese	41·103
Sulphur	24·227
Silicon	0·803
Phosphorus	0·345
Combined carbon	0·214
Graphite	2·468
Titanium	2·768
Nitrogen	0·270
	99·922
Manganese sulphide...	64·76

No. 1.—Section from a mass containing two-thirds of its weight of nearly pure MnS.
White=iron. Half-tone=MnS.
Dark=graphite×56.

No. 2.—Iron from a Wigan basic furnace. Section of a columnar mass. ×5. Dark spots. Graphite in a spheroidal condition in a ground mass of pearlite.



No. 3.—Same as No. 2. A spheroidal particle of graphite×30.



No. 4.—Separated blue crystals of titanium dicyanide × 50, with inset showing a bright face of one of the crystals×330.

Excluding the magnetic iron, graphite and the titanium compound, the mixed sulphides contained :—

	Per Cent.
Manganese sulphide	98·5
Iron sulphide	1·5
	100·0

Here, again, the mixed sulphides were dove coloured and there was only one constituent present.

Mr. Cochrane has kindly supplied drawings in section showing the dimensions of the bears in Nos. 2, 3 and 4 Ormesby furnaces (Figs. 1, 2, and 3). The specimen referred to was obtained from No. 3 furnace (Fig. 2). It will be seen that the metal had not only worked its way downwards, but had travelled laterally. The diameter of the hearth was 10 ft., but that of the bear averaged 18 ft. 6 in., so that the metal had fluxed away about 4 ft. of brickwork on each side under the walls of the hearth itself. The conditions were here most favourable for the lodgment of the ascending sulphide at the points A A.

SECTION IV.

Cyano Nitride of Titanium.—Percy,* in his treatise on "Iron and Steel" refers to the interesting substance exactly like copper in colour which on analysis by Wöhler gave the following result :—

	Per Cent.
Titanium	77·26
Nitrogen	18·30
Carbon	3·64
Graphite	0·92
	100·12

* Percy, Iron and Steel," 1864, page 511.

It is described as nitro cyanide of titanium, $TiCy + 3\,Ti_3N$.

It is found crystallised "in minute cubes piled up, exactly as sometimes occurs in octahedrons of fluorspar."

Every blast furnace manager has noticed it.

Dr. Sorby was the first to find microscopic crystals of the same substance in pig iron, and for that reason Howe gave them the name Sorbite, a term afterwards withdrawn, as the same name was given by Osmond for one of the transition conditions in carbon steels.

It is known that titanium has a strong attraction for nitrogen, and that probably as nitrogen and carbon exist in pig iron, they unite to form crystals.* 'Wöhler, obtained the same substance artificially by heating a mixture of ferro-cyanide of potassium and titanium dioxide in a well-closed crucible at a temperature sufficient to melt nickel. Titanium cyano-nitride can also be prepared by heating to whiteness a mixture of titanium dioxide and charcoal in a tube of gas-carbon in a stream of dry nitrogen (Deville and Wöhler). A third method of preparation is to fuse potassium cyanide in the vapour of titanium tetrachloride (Wöhler). It has a specific gravity of 5·28, and is only attacked by a mixture of nitric and hydrofluoric acids. When ignited in a current of steam it is decomposed as follows :—

$$Ti(CN)_2,\ 3Ti_3N_2 + 20H_2O = 2HCN + 10TiO_2 + 6NH_3 + 10H_2.$$

"Chlorine also decomposes this substance at a red heat, titanium tetrachloride and a volatile sublimate consisting of a compound of titanium tetrachloride and cyanogen chloride being formed. When fused with potash, ammonia is given off, potassium titanate being produced."

As there is titanic acid in the Cleveland ironstone and in the ash of the coke, it is not surprising that in the presence of nitrogen and carbon at a high temperature the copper-coloured compound is produced.

Probably no "bears" are free from the crystals. T. W. Hogg (British Association, 1873) discovered the same copper-coloured crystals associated occasionally with titanium carbide and nitride in ferro-manganese. "Their diameter generally lies between one ten-thousandth to one-thousandth of an inch." "There were," Mr. Hogg informs us, "about half a million of these crystals in 1 cub. cm. of the metal. The largest percentage by weight was 0·032 per cent.

"They had a high metallic lustre with brilliant mirror like facets and were in the form of cubes, octahedra, and forms resembling icositetrahedrons. Their specific gravity varied between 4·1 and 5·1, and the percentage of titanium between 60·5 and 79·8 per cent."

There can be no doubt that the titanium compounds are slightly soluble in molten cast-iron, and that they crystallise out of solution as the metal cools. As they are specifically lighter than cast-iron one would expect them to rise to the surface, but there is no actual evidence that they do so. The reason why they accumulate in some parts more than others and segregate into relatively large masses may be explained by assuming that the first crystals that form adhere to some solid body and they become crystallic centres of attraction, just as a minute crystal of alum suspended in a slightly supersaturated solution attracts to itself the alum from the solution and develops to large dimensions. In the case of the titanium compound, which is in very minute quantity in the fluid iron, it can be reasonably assumed that the metal moves about by convection or other agencies, and after parting with its titanium salts moves away to be replaced with fresh metal, and from this, in turn, is attracted the titanium compound it contains. This process being long continued, it is not surprising, although the fluid iron may not contain more than 0·01 per cent., that masses of several pounds in weight are obtained. If the weight of the fluid metal was 200 tons, and all the titanium compound in it were concentrated at one place, the weight of the crystal mass would be 450 lb. Of course only a fraction of this would actually grow on the first formed crystals, and the calculation only goes to show that there is an ample amount to account for what is found.

SECTION V.

Titanium Di-cyanide or Carbo-Nitride of Titanium. (*Cochranite.*)—Hogg referred to titanium cyanide and carbide as having been found in ferro-manganese, but he does not appear to have isolated a sufficient quantity on which to make analyses. Dark blue crystals have been noticed in bears from one of the furnaces of Messrs. Bolckow, Vaughan and Co., Limited, at their Eton works, and in bears from Nos. 2 and 4 Ormesby furnaces, but it was not until September, 1917, that Mr. Alfred Cochrane handed to the author a specimen from his No. 3 furnace that a sufficient quantity could be obtained for analysis. The specimen, weighing several pounds, had a peculiar fracture closely resembling very dense close-grained magnetite. On moving the fractured surface of the specimen about under incident rays of light there appeared areas ¼ in. to 1 in. across which reflected the light more freely than other parts, suggesting masses of separate minute crystals all oriented alike. The large lump was too hard to saw or drill, and in order to obtain it in suitable form for micro and chemical examination, it was broken up into pieces and crushed to powder.

In the study of all complex alloys of unknown composition it is advisable primarily to examine microscopically polished and etched sections, for in that way one discovers what constituents are present, how they are affected by etching reagents, and, having noted these, the chemical methods for their determination can be arranged. Following this plan, the polished specimen, without etching, was examined with the following results : The greater mass consisted of what appeared to be cuboidal crystals in a matrix of iron associated with segregations of graphite and what appeared to be manganese sulphide. On etching with acid the crystals were not affected, but the ferrous matrix developed a pearlite structure As the crystals were not affected even by strong acid, while the iron and sulphides were readily soluble, it was evident that the crystals could be readily isolated together with the graphite by acid treatment. A small lump was therefore digested in strong hydrochloric acid till there was no further evolution of hydrogen gas. The piece retained its original shape, but was readily reduced to a powder in a mortar. The powder thus produced was washed in running water, which carried away most of the graphite and the very fine crystals, leaving as a residue a mass of dark blue crystals which retained their bright crystal faces. Under the microscope these appeared to be cubical in form. Photograph No. 4 represents these, and the inset the face of a single crystal viewed when examined under vertical illumination and magnified 330 diameters. Analyses of the original specimen and the separated crystals were made with the following results :—

	Original Metal. Per Cent.	Blue Crystals. Per Cent.
Iron	48·493	0·200
Manganese	2·988	trace
Sulphur	1·950	0·027
Silicon	1·490	trace
Phosphorus	0·365	nil
Combined carbon ...	3·723	9·741
Graphite	3·381	1·550
Titanium	33·100	76·864
Nitrogen	4·510	10·545
	100·000	98·927
Specific gravity ...	5·650	4·667
Manganese = MnS ...	4·74	
Sulphur as FeS	0·26	

The blue crystals were capable of scratching the polished face of the hardest steel, and must have a hardness exceeding 700 Brinell. Rubbed between polished faces of quartz, the quartz was scratched.

An analysis corresponds to $Ti(NC)_2$ or di-cyanide of titanium or titanium carbo-nitride, namely :—

	$Ti(NC)_2$. Per Cent.	Found. Per Cent.
Titanium	76·864	instead of 76·864
Carbon	9·141	„ 9·741
Nitrogen	10·540	„ 10·540

It is quite possible that the carbon determined included

* "Treatise on Chemistry," Roscoe and Schorlemmer, "Metals" part ii, page 802.

some graphite and is higher than the truth, for there was difficulty in its complete separation. As there is some doubt as to what the true chemical constitution actually is, the author has given it the mineralogical name of Cochranite, as it was first found in quantity at the works of Messrs. Cochrane and Co. by Mr. A. O. Cochrane. The calculated constitutional analysis of the original metal is approximately as follows :—

	Per Cent.
Iron with silicon and a little carbon ...	50·00
Titanium di-cyanide	41·80
Graphite	3·20
Manganese sulphide	4·74
Iron sulphide	0·26
	100·00

These blue crystals were referred to in a paper by the author read before the Cleveland Institution of Engineers in 1914, and were first found in the bear of No. 5 furnace at the Cleveland works, but they were mixed up with the red titanium compound described by Percy, and as it was impossible to separate them, the composition could not be determined. They are entirely different from the red compound analysed by Wöhler, as will be seen from the composition of each.

	Red. Per Cent.	Blue. Per Cent.
Titanium	77·26	76·864
Nitrogen	18·30	10·540
Carbon	3·64	9·741
Chemical formula ...	$TiCy + 2Ti_2N$	$TiCy_2$

The dark blue crystals, on heating to above redness in a muffle, glowed, and in an hour all the carbon and nitrogen passed away, and the residue consisted entirely of titanic acid associated with a trace of oxide of iron.

The exact position where this specimen was found in the bear is not known, but its low specific gravity, the associated graphite and manganese sulphide, lead one to suspect that it floated up and lodged under the over-hanging brickwork shown in Fig. 2.

(To be continued.)

THE AIR SUPPLY TO BOILER ROOMS.*

By Mr. RICHARD W. ALLEN, C.B.E.

THE subject of air supply to boiler rooms, where closed stokeholds are employed, is one requiring the greatest attention, especially where oil fuel is used, as this necessitates high air pressures being maintained in the boiler rooms. The power absorbed in driving the fans is considerable, and any improvement which can be effected by increasing the efficiency of the system, with a consequent saving in steam consumption, reduction in weight and space occupied, will have some influence on the speed of a ship.

1. *Air Pressure Required to Produce Air Speed.*—Theoretically an air pressure of 1 in. water produces 67 ft. per second air velocity, but this does not allow for any practical losses. It will therefore be more correct to work on the basis of 1 in. water-gauge pressure producing 54 ft. per second. Within the range of speed and of air pressure actually employed on board ship, the speed varies as the square root of the pressure difference. Assuming the calculation to be made for an exit nozzle, consisting of a short cylindrical pipe P P_0 in Fig. 1, with ends not rounded off, we should find that an air pressure of 1 in. water gauge would produce approximately a speed of 54 ft. per second.

The expansion of the formula, with the coefficient underlying our calculations, is as follows :—

V = Exit velocity ...	$= C\sqrt{2gv(P - P_0)}$ ft./sec.
g = Acceleration due to gravity	= 32·2 ft./sec.
v = Specific volume of atmospheric air (at 70 deg. F.) ...	= 13·2 cub. ft./lb.
$P - P_0$ = Pressure difference	= 5·2 lb./sq. ft. for 1 in. W.G.
C = Coefficient of flow : For flow without loss	= 1·0 (theoretical).
For cylindrical pipe without rounded ends	= 0·8 (practical).
∴ Exit velocity due to 1 in. W.G. ...	$= 1\sqrt{2\times32\cdot2\times13\cdot2\times5\cdot2}$ = 67 ft./sec. (theoretical).
or,	= 0·8 × 67.
	= 54 ft./sec. (practical).

On the basis of the above formula (with C = 0·8), the following table gives the corresponding air pressures in inches water gauge required to produce given air speeds in feet per second :—

Ft. per Second.	In. W.G.
20	0·13
25	0·202
30	0·29
40	0·52
50	0·81
60	1·16
70	1·58
80	2·07

2. *Velocity of Air in the Air Shafts.*—The speeds to be recommended are from 20 ft. to 25 ft. per second. The pressure required to produce this velocity is relatively small, viz., 0·13 in. to 0·20 in. W.G., but increases in the ratio of the square of the velocity, so that to produce double the air speed four times the pressure is necessary, and to produce four times the speed requires 16 times the pressure. It frequently happens that most of the velocity energy of the air is lost, which means that the fan must be designed for the extra pressure corresponding to the air speed, if the required output is to be obtained. For this reason a low air speed is desirable, as it reduces the work to be performed by the fan for a given air pressure to be produced in the boiler room. That air trunks are sometimes constructed necessitating very high speeds is proved by several recent cases brought to the author's notice on four different classes of ships, as follows :—

	Ft. per Sec.
Ship (*a*)	48
„ (*b*)	62
„ (*c*)	78
„ (*d*)	65

In every case the velocity is excessive, especially for air shafts as at present designed. In many classes of ships difficulties have been experienced in obtaining the specified air pressure in the boiler room, necessitating modification by increasing the areas of the suction trunks, with satisfactory results. It must be remembered that to obtain a speed of air a pressure difference has first to be set up; this pressure energy then is converted into velocity energy, the greater part of which subsequently gets lost, as very little of the speed is converted back to pressure. Therefore, the higher the air speed, the greater will be the loss. As stated, it is a difference of air pressure that causes a flow of air, and expressed in this way the statement applies equally to suction or discharge, i.e., to pressures above or below the atmosphere.

3. *Enlargements and Restrictions in the Air Passages.*—From tests taken for steam in connection with investigations for nozzles, it must be assumed that the interposition of a chamber C, in a pipe run, Fig. 2, causing a sudden enlargement in this pipe, even if this chamber were of no great length in the direction of the axis of the pipe run, is sufficient to destroy completely the speed of the fluid approaching the chamber through the first portion of the pipe, and making it necessary for a further pressure drop to be expended in order to produce the speed afresh in the outgoing pipe. A case of such enlargement often presents itself where the air shaft leading from the top deck down to the fan compartment emerges into the fan compartment.

It often happens that such sudden enlargements and restrictions occur not at one place only in the passage from the top deck to the fan inlet eye. The loss would then be present as often as such a step occurs in the passage. It could be considerably reduced by replacing the sudden enlargement by a well-tapered trunk giving a gradual enlargement. This, however, is frequently impossible owing to structural considerations on board ship. Therefore, to be on the safe side it is as well when making calculations, to assume that the whole of the energy represented by the air velocity is destroyed, and when designing the intakes to allow for moderate air speeds. As the usual speeds to be recommended are from 20 ft. to 25 ft. per second, the losses where those speeds are adopted are not very great, though appreciable if they occur frequently in the air passage. But with double these speeds the fan must be designed to produce a higher air pressure, amounting to ¾ in. W.G. for every time the loss occurs from the entrance of the air on deck to the fan room. There are many points in the air passage where restrictions in area are frequent. It would be well to enumerate the chief causes :—

(*a*) Restriction due to the casings which stand just underneath the air shafts, thereby reducing the area available for the junction between the air shaft and fan-room. Speeds up to 40 ft. and more are often occasioned by this arrangement.

(*b*) The fan compartments are often too narrow, thereby restricting the area of access to the inlets of the fans placed amidships. This could be improved by the side of the fan casing not reaching up to the deck of the fan-room, as this would make available the area between the fan casing and the deck, and reduce the velocity of the air.

(*c*) The deck coaming on the intake shaft is sometimes carried a considerable distance into the fan compartment below the deck level. This coaming may be arranged so that it does not seriously restrict the area of the fan compartment, by making it narrow, or if deep by cutting away or opening out.

(*d*) Bearer girders and stiffening plates are a frequent source of restriction of area. These may have holes through the webs without seriously impairing their strength.

(*e*) The covers for the fan impeller inlets should fold back flat on the casings. They are frequently prevented from doing so by some obstacles on the plating behind them, or because the vertical stiffeners are situated close to the eye of the fan.

(*f*) The arrangement of the steam pipes also makes a great difference. As an example, a number of pipes one behind the other causes no greater reduction of cross area than one pipe, whereas side by side the reduction would be directly proportional to the number of pipes.

(*g*) Sharp bends in the air shaft cause losses in speed and pressure, and bends should therefore always be made of large radius, or have easy curves without any sharp corners. A particular instance where this is necessary is when the air passage is led under and in between the smoke uptakes.

(*h*) The restriction of area caused by stowing spare gear, lockers, electric distribution boxes and other impediments in the intake shafts should be carefully weighed against the convenience offered.

(*j*) Girders and angles, though not generally abnormal, sometimes cause a considerable restriction in the intake shaft, and where their presence is unavoidable they ought to be carefully encased in sheet steel shrouds of a stream-line design.

(*k*) The area of entry through cowl or hood to the intake shaft is frequently restricted, due to position, shape and height of neighbouring obstacles.

(*l*) Restriction due to the interposition of gratings. Because air is invisible it is not generally sufficiently grasped that it is a body. The air passages should therefore be regarded as pipes or conduits for steam or water, and not as convenient open spaces performing no function.

4. *Deck Intake, Cowl and Weather Flaps.*—The design of the deck intakes, with their cowls and weather flaps has been so greatly influenced by the requirements of protection from waves and spray in bad weather, that less attention has been given to the proper admission of air without loss or restriction. Frequently the area of admission is found to be insufficient, or part of that provided is ineffective. Also, the shape of the passage of air into the shaft makes the entry difficult. When the weather flaps come into operation to shield against wind and sea, the entrance of air practically ceases correspondingly. The difficulty of getting the air into the shaft becomes greater as the speed of the ship increases, and trouble may be encountered, particularly on fast vessels. Many different types of deck intakes, including cowls and weather flaps, have been tried, the design depending upon the situation of the intake and its surroundings on the ship, as well as the class of vessel and the work for which it is intended.

A series of experiments has been made to establish the relative efficiency of different types of air intakes, including the designs generally in use, and also to discover the most efficient shape of entrance to conform to the natural line of flow. The essential requirement was to provide a guide which would perform the protective duty but at the same time induce the flow of air into the shaft, especially when partially closed against the weather. The design proposed to replace the existing shapes offers a marked improvement in efficiency, namely, 83 per cent. against 35 per cent. The comparative tests are contrasted in Fig. 3. The theoretical curve of pressure drop due to velocity with perfect flow is given on the same graph, so that a comparison may be effected. The guides or shields are of stream-line section, and pivoted to the top of the air intake shaft so that they can be opened any desired amount. The stream-line weather flap fitted to cowl is illustrated in Fig. 5, and is contrasted with the shape of cowl and weather flaps fitted in the past, shown in Fig. 4. Two recent innovations, namely the centre guide and nozzle, are embodied in the deck entry, and are also shown in Fig. 5, the centre guide in the form of a deflector or inverted pyramid attached beneath the cowl top, and the nozzle providing a *vena contracta* flow at the entrance to the intake shaft.

In explanation of the manner in which the centre guide and nozzle contribute to prevent loss of pressure, it has been proved that where these contrivances are not provided the whole of the space which they occupy is filled with eddy currents which are continuously absorbing energy. The reason for the formation of the eddies is partly that the direction of the air is changed on entering the shaft and owing to its velocity sweeps round the corners, and partly owing to the law of *vena contracta* for the flow of all fluids, either liquid or gaseous, at entrance or exit of duct. The centre guide and nozzle conform to the correct line of flow to prevent the formation of any eddies. Another improvement to which importance is attached is fitting of the diaphragms, placed athwartships, sub-dividing the air intake shaft. When a ship is travelling at a high speed there is a tendency for the air to rush past the intake without being drawn in, and for the air which does enter to bank up in the after side of the intake shaft, with a consequent tendency to starve the forward fans. By fitting diaphragms the tendency to unequal air supply fore and aft will be efficiently counteracted, and all the fans will receive their due share of air.

5. *Velocity of Air at the Eye of the Fan.*—The velocity of air through the fan eye depends very largely on the design of the fan and the type of the driving motor. With an engine-driven fan the inlet eye can in most cases be made large enough to keep the inlet speed low without reducing the radial length of the blades too much. With a steam-driven turbine fan, in order to obtain an efficient turbine, the revolutions per minute must be kept fairly high, thereby reducing the fan diameter necessary for a given pressure. In order to keep an effectual radial length of blade the inlet eye must be reduced as compared with an engine-driven fan, and the entrance air speed accordingly increased. Since the introduction of the new design of fan, in the year 1910, the tendency has been to reduce the diameter of the fan still further, so as to economise in space required for the fan installation. In order to obtain at the same time higher fan efficiencies, thereby reducing the driving power required, the velocity of the air at the eye must always be very carefully considered. It is generally desirable not to exceed a speed of 40 ft. per second.

6. *Necessity of Fitting Suitable Inlet Rings.*—It has repeatedly happened that a fan has failed to deliver its designed output, and on examination this has been found to be due to an inlet ring badly fitted to the fan eye, or to an inlet ring of unsuitable shape. It is, therefore, important to give proper consideration to this item, and to pay attention to the following points : (*a*) Correct clearance, (*b*) angle of entry, (*c*) avoidance of sharp corners. Greater clearance has a direct influence on the amount of leakage, i.e., on the slipping back of the air from the pressure side to the suction side, and a

* Paper read at the Spring meetings of the fifty-ninth session of the Institution of Naval Architects, March 22, 1918.

more direct influence on the air stream entering the fan eye, inasmuch as an increased leakage causes increased restriction to the area for the flow of the air.

The angle of entry has an important effect on the efficiency of flow of air along the impeller vanes, as well as on the effective area of inlet to the fan eye. Sharp corners set up eddies. Different shapes of inlet ring are illustrated in Figs. 6 and 7, including one of recommended design with correct clearances.

Fig. 6 shows a ring of normal section, which takes no account of the natural path of the air entering the fan eye. In addition, the sharp corner is a source of loss.

Fig. 8, page 664, shows the result on the air stream. The effective area of fan eye is reduced, the velocity of entry increased, and consequently the momentum of the air in the direction parallel to the axis of the fan.

Fig. 7 illustrates an inlet ring designed on correct principles, which may yet be simply constructed, being made of steel plate flanged.

Fig. 9, page 664, shows how the *vena contracta* is increased in area, and the velocity at entry thereby reduced. With the lower momentum and removal of the outer eddies, the radius of change of direction of the air becomes smaller.

7. *Stream-line Shutters for Fan Inlets and their Influence.*—Owing to the elastic nature of air a current is generally accompanied by a series of undulations and pulsations. The relative internal directions of motion at different parts of the stream may be examined at any required moment by the aid of instantaneous photography. In the case of air approaching the suction inlet of the fan this action has a marked influence. In centrifugal fans of high efficiency the vanes are so designed as to coincide with the direction of the vectors of the compounded velocities of the air. Therefore since the vanes are fixed, in order that they may operate most efficiently it has been found desirable to guide the air at the entrance to the fan-eye in parallel streams, normal to the fan inlet, and also to correct or dim the pulsations. The influence on the air is far more marked after its passage through the stream-line shutter than during the approach, and therefore the photographs (see page 668) do not show the full extent of the correction. Evidence of the beneficial influence of the stream-line shutter is provided by tests.

A series of tests was carried out on a comparative basis, and a fan equipment was selected which was fitted with a wire screen over the fan inlets under conditions mentioned below. The output of the fan was first tested with this arrangement and subsequently removed, and in place the stream-line shutter was fitted. The results are given in Fig. 11 recording the increase in air pressure and quantity of air.

When a fan is stopped, the inlet eye is closed to prevent the air escaping from the boiler room through the stationary impeller back to the fan compartment. For this purpose there are provided hinged folding doors of steel plate, and also loose covers, which have to be fitted and closed to make an airtight joint. The chief objections to these doors are that, besides being inconvenient to construct, they are troublesome, and require much time to manipulate in practice, particularly in a ship installed with a large number of fans. To avoid mislaying the loose covers, these are screwed against the fan casings when not in use, and much time is lost in consequence. Another serious objection consists in that the hinged doors when open can seldom be made to fold back to allow free entrance of the air to the fan, owing to the vertical stiffening girders on the fan casings, or other members, with which they come in contact.

When folding doors are fitted it is necessary to fit a wire guard to protect the impellers from articles which might be drawn in, and these guards further affect the air inlet to the fan. A great improvement in these conditions has been introduced with the fan-eye shutter, which replaces the loose and hinged folding doors and the wire guard. It can be opened or closed instantaneously by moving a handle. The shutter, illustrated in Fig. 10 consists of a number of slats operated by a connecting bar or bars. A lever is attached to the pivot of each slat, and the ends of the levers are attached to a connecting bar at the end of which is an operating lever and handle. The slats are preferably "stream-line" in cross-section, and each slat consists of a bar of "stream-line" cross-section, to which is riveted a thin metal plate. When the shutter is closed the end of one slat engages with the adjacent slat, and makes an airtight connection with it.

8. *Loss of Air Pressure in the Boiler Room due to Vacuum at Fan Inlet.*—If, in the passage from the top deck down to the fan inlet, a loss of air pressure occurs, say of 1 in. water gauge, due to sudden enlargements, high speeds and sharp corners, then in order to draw the air into the fan-room a vacuum of 1 in. must be produced by the fans themselves. Therefore, if a fan designed for 4 in. water gauge of pressure in the boiler-room has first to produce 1 in. water gauge of vacuum in the fan compartment in order to draw the desired quantity of air through the air passages, then obviously it can only maintain 3 in. on the discharge side, *i.e.*, in the boiler-room, instead of 4 in. water gauge. Exhaustive tests have been carried out which prove that the air pressure in the boiler-room equals the total pressure exerted by the fan less the amount of suction at the fan inlet. The tests were conducted on a forced-draught fan, 60 in. in diameter, and typical readings are as follow :—

R.P.M.	Cub. Ft. Air per Min.	Total Press., In. W.G.	Suction, In. W.G.	Discharge Press., In. W.G.	—
450	5,000	3·05	0·15	2·9	Suction open and discharge throttled.
450	4,590	3·04	2·9	0·14	Suction throttled and discharge open.
450	10,000	3·75	0·25	3·5	Suction open and discharge throttled.
450	9,000	3·74	3·5	0·24	Suction throttled and discharge open.

Fig. 1.

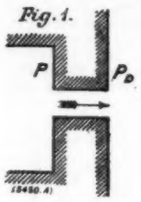


Fig. 2.

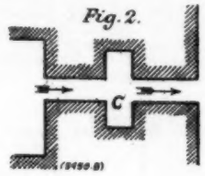


Fig. 4. OLD TYPE COWL WITH FOUL WEATHER FLAPS

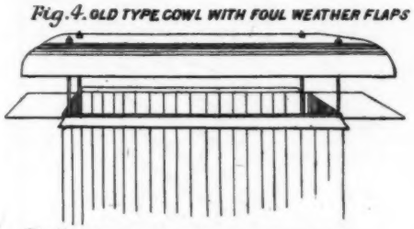


Fig. 5. NEW TYPE COWL WITH FOUL-WEATHER FLAPS WITH CENTRE GUIDE & NOZZLE

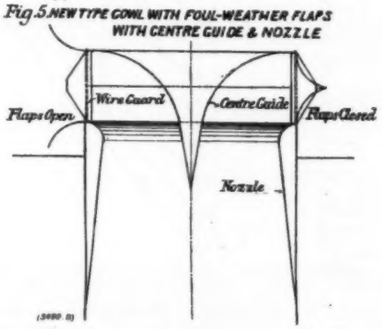


Fig. 6.

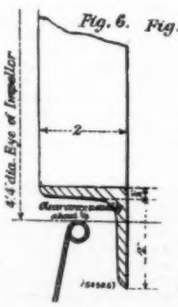
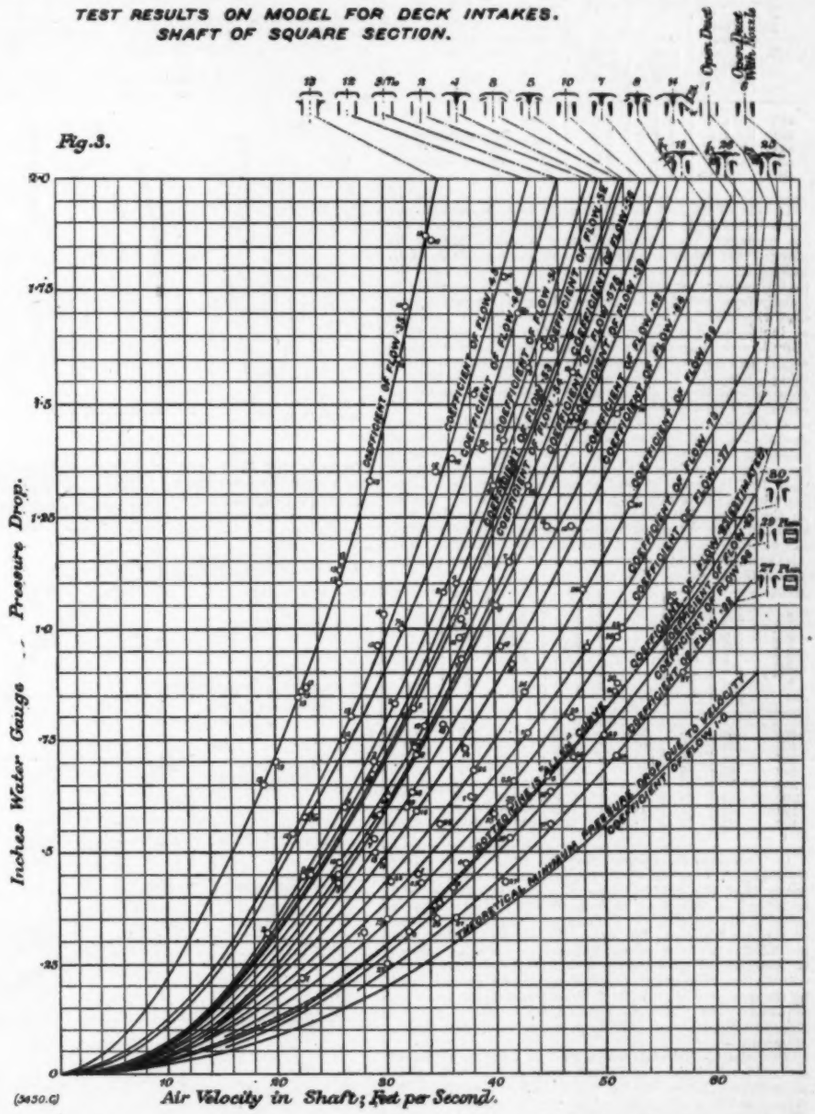


Fig. 7.

TEST RESULTS ON MODEL FOR DECK INTAKES. SHAFT OF SQUARE SECTION.

Fig. 3.



The results show that, for a given speed of revolution and quantity of air, the total pressure across a fan is constant, and if a resistance is placed in the fan inlet, causing a rise in vacuum, there will be a corresponding fall in discharge pressure. It is therefore proved that :—

1 in. W.G. vacuum on inlet side means 1 in. W.G. drop in discharge pressure.
2 in. W.G. vacuum on inlet side means 2 in. W.G. drop in discharge pressure.
3 in. W.G. vacuum on inlet side means 3 in. W.G. drop in discharge pressure.

The readings given in the table below are the outcome of tests on board ship, and they show that of the total air pressure which the fan installation on this ship is able to maintain at maximum output fully one-third is wasted in losses of flow through the intake shaft, making only two-thirds available for the boiler-room.

R.P.M.	Total Press. across Fan, In. W.G.	Loss in Intake Shaft, In. W.G.	Press. in Boiler-Room, In. W.G.	Volume of Air entering Stokehold.
430	4·6	0·1	4·5	NONE
450	4·4	1·1	3·3	Depending on varying number of furnace flaps open.
435	4·2	1·4	2·8	
430	4·2	1·6	2·4	
430	3·8	1·55	2·25	MAX.

In view of the fact that the design of a ship sometimes necessitates high velocities and certain obstacles in the air passages, the possible losses produced should be allowed for when considering the design of the fan. Taking in consideration the characteristic curves of the performance of centrifugal fans, it would be desirable to specify fans designed for increased air pressures, beyond that which is necessary for smokeless combustion, instead of increased quantities, as is frequently done, when there is any danger of air shortage. By this means there would be a reserve of pressure to overcome resistances in intake passages if they occur. At the same time a greater supply of air to meet emergency conditions would still be available.

9. *Increase in Steam Consumption of Fan Installation due to Vacuum at Fan Inlet.*—From the many steam consumption tests which have been made from time to time on various sizes of fans and engines, it may be taken that the increase in the steam consumption of fan installations is about 20 per cent. due to 1 in. vacuum on the inlet. This loss is considerable, especially with large numbers of fans, and shows the necessity of reducing the vacuum on the inlet side to the lowest possible limit. An example of a steam consumption table for an engine-driven fan is given below :—

Revolutions per Minute.	Steam Pressure, Lb. per Sq. In.	Back Pressure, Lb. per Sq. In.	F.H.P.	Lb. Steam per Hour.	Lb. Steam per F.H.P. Hour.	Water Pressure, In. W.G.	Quantity, Cub. Ft. per Minute.
445	150	25	23·4	2,784	98·0	4·5	40,000
400	127	25	20·4	2,237	109·0	3·7	35,000
350	108	25	13·8	1,788	129·5	2·9	30,200
300	85	25	8·87	1,282	144·0	2·15	26,100
250	70	25	5·4	942	174·0	1·55	22,200
200	54	25	2·6	620	238·0	0·96	17,100
150	42	25	1·11	390	351·0	0·55	12,700
100	34	25	0·356	235	660·0	0·26	8,850

10. *Increase in Output due to Properly Designed Casings.*—A number of tests have been made which prove that the performance of a fan is considerably improved in output as well as efficiency if attention is given to the design of the fan casing, and to the discharge of the air from the fan case. Where fan casings are provided it is of the utmost importance that they should be constructed as a volute form, designed specially to suit the exact conditions for each ship, which are governed by the quantity of air to be delivered and the air pressure required. The following tests, carried out on various sizes of fans, illustrate the importance of correct design of casing.

Test No. 1.—The fan was tested in a volute casing of a considered design, and tests were also carried out in an ordinary volute casing which had not received the same careful study with a view to maximum output. The results, illustrated in graphical form, Fig. 12, show that the output was approximately 10 per cent. greater at normal duty with the improved design than with the ordinary volute, when fitted to the same fan running at the same speed.

Test No. 2.—The fan was first tested in a concentric casing. Secondly, the same fan was tested in a casing of volute shape. The improvement effected by the second test over the first amounted to 30 per cent. in output, and 9 per cent. in efficiency (efficiency being raised from 36·8 per cent. to 40·3 per cent.). The average readings are given from the tests.

R.P.M.	Quantity, Cub. Ft. per Min.	Pressure, In. W.G.	Fan Efficiency.	—
450	10,600	2·98	36·8	Concentric casing.
450	13,800	2·96	40·3	Volute casing.

Test No. 3.—The fan was tested in a concentric casing without volute, and also in the same casing with a volute introduced. The superiority of the volute casing over the concentric casing amounts to approximately 70 per cent. in output, and 20 per cent. in efficiency. Average readings are given from the tests.

R.P.M.	Quantity, Cub. Ft. per Min.	Pressure, In. W.G.	Fan Efficiency.	
510	27,600	4·95	42·0	Concentric casing.
515	28,700	5·00	43·0	
523	30,600	5·10	43·7	
496	42,750	5·35	64·8	Volute casing.
492	31,000	6·00	66·8	
497	25,200	6·20	64·3	

Numerous comparative results have been recorded, from which the readings quoted have been selected to illustrate the value and emphasise the importance of the question of the fan casing.

11. *Arrangement of Deflectors on Fan Casings.*—When several fans are placed side by side, as is often the case in the fan compartment of a boiler-room, it is found that some of the air delivered from one fan obstructs the delivery of air from an adjacent fan, thus diminishing the output. This objection is overcome by the employment of guides or deflectors of special form. When two adjacent fans are revolving in opposite directions the guide or deflector is of a form resembling a four-sided prism with concave faces. Where fan casings are fitted, two of these faces form continuations of the curves of the two casings, the edge formed by them being situated between the two impellers at or near the point where they are nearest to each other, whilst the opposite edges of these faces are each in close proximity to its impeller. The other two faces of the prism form guides which turn the two meeting currents of air more or less through a right angle, and so cause them to flow together away from the fans, as illustrated in Fig. 13. When the adjacent fans revolve in the same direction the deflector is three-sided, one edge, as before, being situated between the impellers, the two faces meeting at that edge being continuations of the curves of the casings, whilst the third face forms a guide which directs the air from one impeller into the same direction as the stream delivered from the other impeller, as shown in Fig. 14.

The result on the air streams issuing from a fan casing, with deflector fitted, is illustrated in Fig. 15. Without deflectors, after concussion of the opposite streams, the air in its endeavour to follow a natural path tends to form deflecting planes by the formation of eddies. The deflector saves both the shock caused by opposing streams and the energy absorbed in the eddies. Where fan casings are not fitted, the form of deflector is more dependent upon individual circumstances. Thus, if a fan runs close to a bulkhead or discharges into a corner formed by the ship's structure, or if part of the periphery runs near some obstacle, the improvement in output and efficiency due to fitting an effective deflector is very appreciable.

Tests were also carried out on board ship with a plant where fan casings were not installed, to ascertain the effect of fitting deflectors. The arrangement of fans in the boiler-room on trial was as shown in Fig. 16. It will be noticed how the direction of rotation is responsible for banking the air up into the recesses formed by the dock above and the air-lock at A A. The rotation was then reversed, and deflectors were fitted as shown in Fig. 17. The effect of the reversal was to make the confined spaces act to some extent as volutes instead of as air pockets. The deflectors which were fitted had been designed to suit the position, surroundings and rotation of the fans. Two series of readings were taken on this ship before and after fitting deflectors, which are plotted on the graph, Fig. 18. The improvement effected with the deflectors is represented by the area between curves B and D. Deflectors have been proved to be of greatest value when the output of air is large or the velocity of the air is high. This necessarily follows, since both conditions are interdependent and have a tendency towards high resistance of flow, which calls for high-pressure drop; thus, for any particular ship the benefit derived would be most when the demand on the fans is at a maximum. In comparing different ships, the larger the quantity of air supplied, or the higher the velocities of air currents, the greater will be the saving effected by the deflectors.

From experiments carried out on speed trials several valuable observations were recorded by means of the ribbon test. It was found that some of the air leaving the fan at high velocity went straight to the furnace doors. These streams may be of great value if guided correctly by deflectors; the losses are then the minimum possible under any conditions, as there are no losses at all incidental to the conversion of velocity to pressure energy and back again. The rest of the air leaving the fans supplies the storage of air in the boiler-room, that is to say, its velocity is changed into pressure energy, which is converted as demanded by the pressure difference across the boiler into the required velocity of air passing through the furnace doors. The storage pressure in the boiler-room produces low-velocity streams radially to the furnace doors from all directions. Considering the value of the high-velocity streams described, much benefit may be derived from avoiding, where possible, any obstacle being placed near the periphery of the impeller. Deflectors should always be arranged so as to guide the streams of air in a correct and natural path. Deflectors should be fitted as close as possible to the periphery of the fan impeller, only allowing a running clearance of about 1 in. The guard round the fan, which has a greater clearance, should be fitted afterwards. Since the velocity of the air streams are highest as they leave the fan, the momentum of the air streams is then at a maximum, and deflectors, which act as a guide to the streams, can be applied with the greatest effect. Recent observations have demonstrated the value of long deflector plates as compared with short ones, and where there is room for them it is desirable to have long plates.

Fig. 8.

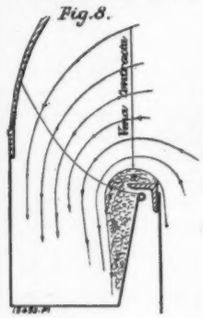
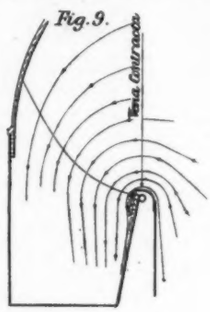
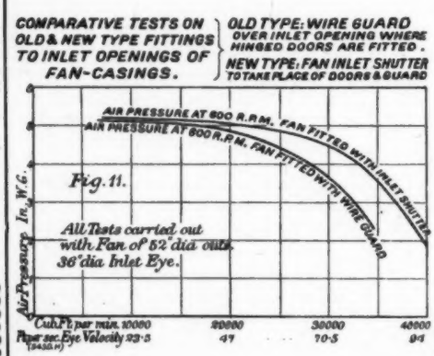
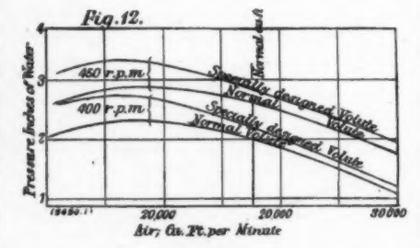
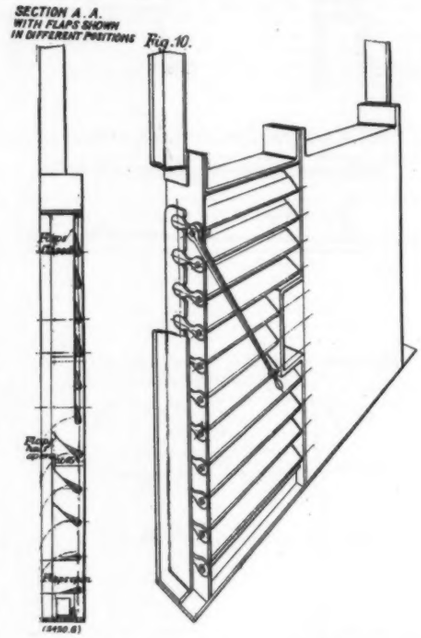


Fig. 9.




COMPARATIVE TESTS ON OLD & NEW TYPE FITTINGS TO INLET OPENINGS OF FAN-CASINGS.
OLD TYPE: WIRE GUARD OVER INLET OPENING WHERE HINGED DOORS ARE FITTED.
NEW TYPE: FAN INLET SHUTTER TO TAKE PLACE OF DOORS & GUARD
AIR PRESSURE AT 600 R.P.M. FAN FITTED WITH INLET SHUTTER
AIR PRESSURE AT 600 R.P.M. FAN FITTED WITH WIRE GUARD
Air Pressure In. W.G.
Fig. 11.
All Tests carried out with Fan of 52" dia. outlet & 36" dia. Inlet Eye.
Cub. Ft. per min. 10000 20000 30000 40000
Paper sec. Eye Velocity 23·5 47 70·5 94





THE AIR SUPPLY TO BOILER ROOMS.

Fig. 13.

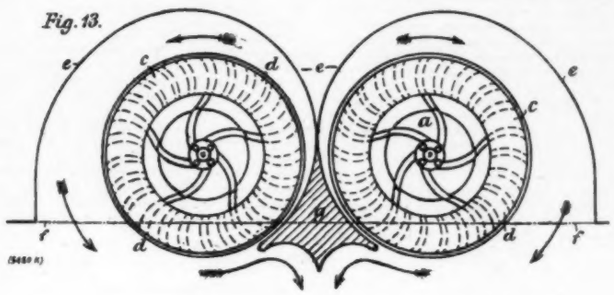


Fig. 14.

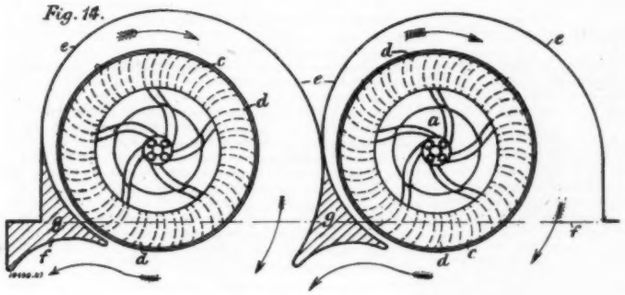


Fig. 15. DIAGRAM SHOWING INFLUENCE OF DEFLECTORS ON AIR CURRENTS.

Preventing (1) Re-entrance of Air into Casing at A.
(2) Obstructing Delivery of adjacent Fan at B.

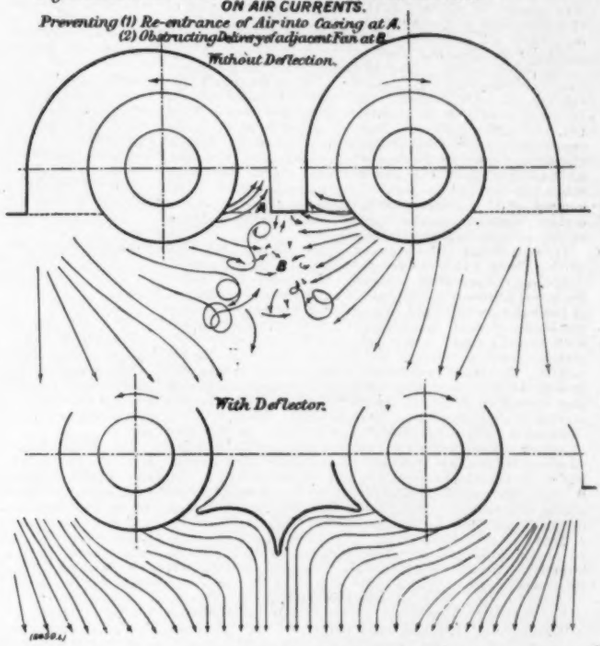


Fig. 16. WITHOUT DEFLECTORS, ORIGINAL ROTATION. ARROW HEADS SHOW STUNTED AIR STREAMS.

Fig. 17. WITH DEFLECTORS, REVERSED ROTATION. ARROW HEADS SHOW DEFLECTED AIR STREAMS.

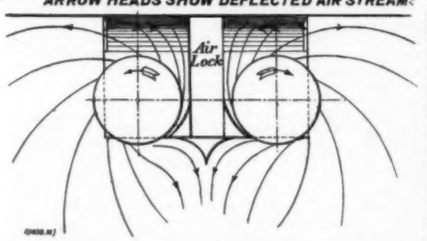
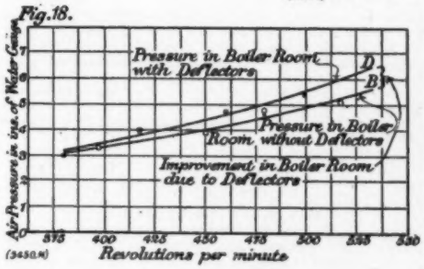


Fig. 18.



so as to deflect the streams of air gradually, and also to act as guide for a greater distance.

12. *Direction of Rotation of the Fans. Influence on Distribution of Air in the Boiler-Room.*—In the disposition of a group of fans in the boiler-room little or no consideration has in the past been given to the influence which direction of rotation of the fan has on the uniform distribution of air in the boiler-room. It is generally assumed that the pressure which the fans create in the boiler-room is sufficient and uniform enough throughout the boiler-room to supply all the furnaces equally with air. The air currents, however, caused by the discharge of air from the fan casing, and also from the periphery of the fan itself where it is open to the boiler-room, are so considerable with the latest types of fans, which have to work against a considerably higher air pressure than formerly, that consideration has to be given to the possibility of such air currents blocking the passage of air to the extreme parts of the boiler-room. The lifts and air locks reaching down into the boiler-room from the fan compartment add considerably to the difficulty of getting the air uniformly distributed. It will be realised that the furnaces of the boilers placed amidships are plentifully supplied with air, whilst the furnaces situate at the wings do not get such a direct and ample air supply. Considerable improvements in this direction can often be achieved by regrouping the fans, and reversing the direction of rotation of the fans, thereby obtaining a uniform supply over the whole width of the boiler-room.

13. *Oil Fuel. Quantity of Air Required for Combustion.*—Most liquid fuels are derivatives of petroleum, which occurs in many different parts of the world, and varies to some extent in composition. Practically the same material is obtained by the distillation of oil shales and some classes of coal. Whatever its source, petroleum always consists of a mixture of different hydro-carbons capable of being more or less completely separated from each other by fractional distillation. The theoretical quantity of air required for complete combustion of the fuel is based on the precise amount of oxygen which that air contains, and assumes that as the air passes through the boiler the whole of this oxygen is completely extracted, and combines with the gases given out by the fuel. Such a condition, of course, is never reached in practice, as each particle of air cannot be brought into contact with the fuel at the correct temperature, and for a sufficient length of time. The amount of excess air required depends upon the type of oil burner, design of boiler, and the conditions of combustion. To arrive at the amount of air required in practice the theoretical amount must be multiplied by a factor which is usually found to be within the range of 1·6 to 2·5, that is to say, the volume of air as measured at normal atmospheric temperature and pressure required for the combustion of 1 lb. of oil fuel is from 250 cub. ft. to 450 cub. ft.

14. *Progress in Fan Design.*—Until a few years ago there were certain rules which were generally accepted and applied for the size of all machinery placed on board ship. In the latest ships, considerations of weight and space, and also of efficiency in working, have become of such vital importance that increasing investigation has been devoted to obtain the maximum output possible with a fan installation of minimum weight and space, absorbing as little power as possible for a specified duty. There are always limiting factors to the increase of efficiency, and to the reduction in size; the greater the improvement achieved the more difficult it is to make further appreciable strides towards reaching the limits. Generally speaking, with the ever-increasing air pressures, and consequent greater air velocities through the fan vanes, together with the large volumes to be dealt with, in order to achieve a maximum all-round efficiency, great attention has to be given to the design of the vanes of modern fans, so as to make the air streams passing through them follow as closely as practical limitations will allow the laws of dynamics with due consideration of the physical properties of the medium one has to deal with.

In conclusion, the author would remark that he has only treated the subject very briefly, as the results of the research work cannot under present circumstances be presented as fully as would otherwise be the case.

We supplement the illustrations in the paper by reproducing, on page 668, the photographs exhibited as wall diagrams at the meeting of the Institution. Figs. 19 and 20 show the air flow at the fan inlet demonstrated by long ribbon tests. These are from actual photographs, the exposure being 2½ minutes. The following table gives the results:—

—	Air Velocity in Inlet	Lost Pressure.	Air Flow.
Fig. 19. Without stream-line shutter	45 ft. per sec.	0.3-in. water gauge	Pulsating and undulating
Fig. 20. With stream-line shutter	45 ft. per sec.	0.00-in. water gauge	Regular

Figs. 21 and 22 show the air flow at the fan inlet by means of short ribbons which were suspended on wires. These also are from actual photographs, the exposure being practically instantaneous namely, $\frac{1}{125}$th part of a second. The following table shows the results:—

—	Air Velocity in Inlet.	Lost Pressure.	Air Flow.
Fig. 21. Without stream-line shutter	45 ft. per sec.	0.3-in. water gauge	Pulsating
Fig. 22. With stream-line shutter	45 ft. per sec.	0.00-in. water gauge	Regular

Fig. 23 shows the inlet and Fig. 24 the air flow through the weather flaps again as demonstrated by long ribbons. The exposure in this case was 3 minutes. The results of illustrations Figs. 23 and 24, are as follow:—

—	Air Velocity in Shaft.	Lost Pressure	Air Flow.
Fig. 23. Old type intake	30 ft. per sec.	1.45-in. water gauge	Contracted
Fig. 24. Intake with stream-line flaps, centre guide & nozzle	30 ft. per sec.	0.28-in. water gauge	Convergent

Figs. 25 and 26 show the stream-line shutters fitted to the fan inlets of a double-ended set the end walls of the fan compartment having been removed for more clearly illustrating the arrangement. Fig. 25 shows the shutter open, and Fig. 26 the shutter closed.

THE JUNIOR INSTITUTION OF ENGINEERS.—On Monday, June 24 next, Sir Wilfrid Stokes, K.B.E., will deliver the third Gustave Canet Lecture at the Lecture Hall of the Institution of Civil Engineers, Great George-street, at 6 p.m., taking for his subject the Stokes gun, one that is very appropriate, considering the eminence of the late M. Gustave Canet as an artillerist. Tickets for the lecture may be obtained (free of charge) from the Secretary of the Institution at 39, Victoria-street, S.W.1.

THE STABILITY OF AEROPLANES.

TO THE EDITOR OF ENGINEERING.

SIR,—On re-reading my article of May 3 in the light of the criticisms in your issue of June 7, I see that there was an error of wording in the article, and that most of the criticisms on the proof as it stands are just. I thank my critics for pointing this out, and am sorry for the trouble I have caused them.

The error is this. The sentence, early in § 3, "Let now the velocities . . . be $(-U+u, v, w)$ parallel to Ox, Oy, Oz" should read: "Let now the velocities . . . be $(-U+u, v, w)$ parallel to its principal axes." With this correction I believe that the proof is sound; the equations do not disagree with those given by Messrs. Cowley and Levy for fixed axes (my v and w are, of course, not the same as their v and w), except that they have taken the forward velocity of the aeroplane to be $-U$ instead of U, a convention introduced by some of the earlier workers on the subject, who were thinking chiefly of models in wind tunnels.

It was Routh ("Advanced Rigid Dynamics," 6th edition, 1905, § 15) who drew attention to the simplification that occurs when a system of moving axes never deviates far from its mean position, and who recommended (§ 15 *b*) the use of fixed axes in such circumstances for the study of small disturbances. Routh was concerned with sleeping tops; I have adapted his method to aeroplanes. Since aeroplanes, unlike tops, have finite linear motion, the linear equations need special treatment. It is in the discussion of the angular motion of aeroplanes that Routh's method is valuable, and it is the angular motion that students find most difficult.

Another criticism is that "my treatment is restricted to a very special case, viz., where the machine is flying at a particular angle of attack." In theory, this is true; but in all practical aeroplanes, as I indicated in § 2, k^2_E is negligibly small compared with k^2_A and k^2_C, for all angles of attack occurring in horizontal flight, and hence this criticism loses its foundation.

I am glad that Messrs. Cowley and Levy agree with me on the importance of meeting the need of engineers, forcibly expressed by Mr. Barling in your issue of June 7, for a simple proof.

Yours faithfully,
H. A. WEBB.

"Southcote," Blackwater, Hants.

COAL ECONOMY AND NATIONAL HEALTH.

TO THE EDITOR OF ENGINEERING.

SIR,—Lord Moulton, speaking at the annual conference of the Institution of Gas Engineers, is reported as having urged that gas and electricity should be placed on an even footing, and charged for in proportion to the amount of energy (heat) supplied to the consumer. This would mean that a quantity of gas or a quantity of electric energy, each equivalent to the same quantity of heat units, would cost the consumer the same amount of money.

On this basis, if electricity were charged for at 1*d.* per unit, then the price of gas would have to be about 12*s.* 6*d.* per 1,000 cub. ft. Of the heat produced by the gas, only a substantially-reduced proportion can be usefully applied to the needs of the consumer, whereas in a well-designed electric fire or oven, there is very small waste of heat. This fundamental difference is due to the inherent necessity of maintaining a draught during the burning of the gas, which draught carries away, into the outside air, a varying proportion of the heat produced by the gas flame. Owing to this inseparable waste in connection with gas-produced heat, it would appear that gas must always be sold at a lower price than electricity as measured by their respective *gross* heating values, because the *net* heating value of gas to the consumer is inferior to the *net* heating value of electricity.

If Lord Moulton is correctly reported, he would seem to be advocating conditions that would give gas a very poor chance in the market, because it is inconceivable that anyone would use a gas fire on such terms of payment. The framers of the new scheme for rationing coal gas and electricity have based their alternatives on sound lines, and whether intentionally or not, allowance is made for waste of gas-produced heat. We are permitted to purchase either 750 heat units from the gas works, or 273 heat units from the electricity works, but the *net* value of these to the consumer will not be in anything like the same proportion. A mere statement of this kind is valueless without some evidence to support it, and I will, therefore, cite, as an example of the extraordinary economy of electrically-produced heat, a test that I recently made of an electric furnace for tempering steel. I found that I was able to maintain the required temperature of 900 deg. C. for one hour, with electricity equivalent to 6,000 heat units (exactly 5,971), whereas the gas-furnace makers, for a furnace of the same size, require a consumption of gas equivalent to 75,000 heat units, which means that 69,000 gas-produced heat units must be blown away to waste in warming the wide world instead of the furnace. In this calculation, I have assumed that the value of the gas is 500 heat units per cub. ft., which is a fair average value.

This brings me to the main point that the 75,000 heat units would call for the carbonisation at the gas works of about 30 lb. of coal, against only about 6 lb. of greatly inferior coal used at the electricity works in attaining the same result. Fortunately, the fine quality coal used at the gas works yields coke and other valuable material for explosives and agriculture; and from the national point of view, the gas works to-day are most important. That is no reason, however, why we should use gas for heating and cooking in a wasteful manner, when it could be very much more efficiently and beneficially employed in developing power in a gas-engine.

A few words should be spoken into the public ear from the point of view of national health. Gas fires have met with considerably-advertised testimony from medical men, but these all insist that the gas fires must be "*properly fixed.*" In other words, the flues must be kept clean, and free to carry away the products of combustion. In my own home, where I have electric fires, as well as the previously-fitted gas fires, I have had to lengthen the flue pipes, and these should project at least 12 in. up the chimney. As originally fixed, the flue pipes terminated under, and did not project into the chimney at all, and the atmosphere of the rooms soon became oppressive and unhealthy. This objectionable feature has been largely remedied by the alteration. I wish strongly to emphasise the view that the country is putting gas to the wrong purpose in using it for heating and cooking, and we are thereby wasting coal.

I am, Sir, yours faithfully,
C. ORME BASTIAN.

185, Wardour-street, Oxford-street, London, W.
June 11, 1918.

GUN EROSION.

TO THE EDITOR OF ENGINEERING.

SIR,—The article, in your issue of the 7th instant, on gun erosion, is very interesting.

The cracks in the bore of a gun are caused, no doubt, in the way put forward by Professor Howe. May I suggest that these cracks continue to enlarge, and lead to the destruction of the inner tube, for the following reason:—

The copper from the band of the projectile is driven into the crack, as explained by Professor Howe—but the copper cannot escape, as it is held tight by the contraction of the tube due to the subsequent cooling. When the next shot is fired, the cracks again expand, and more copper is driven in. This process is repeated, until the inner tube is destroyed by the continued enlargement of the cracks, if not by erosion.

I may point out that a similar state of things occurs, when the arch of a brick-kiln is destroyed, by being forced *upwards*. On firing the kiln the arch expands, the outer joints of the brickwork open slightly, and sand and other foreign substances drop into these open joints, and cannot escape. This operation is repeated each time the kiln is used, until the cracks become so large that the arch is distorted and can no longer support itself. I have known brick arches destroyed in this manner after kilns have been in use for a very short period, where sand has been used as a covering. This is especially the case in arched kilns used for burning blue bricks, due to the fact that, in this instance, the temperature required is much higher and must be maintained for a longer time.

Yours faithfully,
London, June 12, 1918. HENRY WARD.

PAYMENT BY RESULTS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Ramsay, in your issue of May 31, repeats in his opening statement a fact which has been acknowledged and reiterated again and again. The conclusion at which he arrives may or may not appeal to scientific (?) students of labour economics, but it is sensible. The undersigned has often wondered whether almost every article, paper and book written on "Payment by Results" is seriously intended to further this ideal—it is also practical—or is simply an effort in the art of camouflage.

Without going into the details of ordinary (or extraordinary) premium or bonus systems, it is surely absurd to say that if one produces more than the average attainment, he is receiving payment by result if he is paid less per unit. It should also be apparent that an exceptional *psychological* argument is required to convince one that the more he produces in a given time the less he will get per unit, is in accordance with "payment by result"—unless he is to understand the expression as effective only in the direction of penalty.

It is no doubt commercially sound policy to sell certain articles in large quantities cheaper than in small quantities, provided supplies are plentiful, but labour operates differently. As Mr. Ramsay pointed out, increased output cheapens production cost, increases profit, and—improves the competitive position. It involves no abstruse mathematical calculations to prove these statements.

If the principle of "payment by results" is acknowledged, it should be straightforwardly adopted; otherwise it is difficult to confute Ruskin's dictum: "If we once can get a sufficient quantity of honesty in our captains, the organisation of labour is easy, and will develop itself without quarrel or difficulty; but if we cannot get honesty in our captains, the organisation of labour is for evermore impossible."

Incidentally, might it be suggested that the words "scientific psychology," &c., should be given a rest?

Yours faithfully,
London, June 12, 1918. W. J. GROSART.

"DUMPING."

TO THE EDITOR OF ENGINEERING.

SIR,—"One who doesn't know" asks in your last issue who is to pay for protecting our industries? It might enlighten him if he would consider who is paying for the war-time extension of our steel works, for the opening-up of our neglected iron mines, for the creation of tungsten works, for the erection of optical glass works, for the working-out of synthetic chemical problems, for researches in fire-resisting bricks, in short, for the creation of a number of new industries under frightfully expensive conditions.

I imagine from his letter, he is a Cobdenite, and, if so, he holds a strongly logical position, provided all Cobden's assumptions be true. Cobden held that each country should manufacture such articles as it was best fitted to produce, and that it should buy from other countries what they could best produce. This assumes that every country will do business on commercial principles, but it does not cover the case of a country which, while buying and selling, is always looking forward to "the day" when it can throw its sword into the scales, and demand its weight in gold. The German public paid millions to supply us with dumped steel, but for every million they expected to get ten millions, either from us or from our Allies. Although the speculation has failed, it was very promising at one time. But how far will the money we saved by using dumped steel go towards defraying the cost of the war? Will it pay two days' expenses?

Yours truly,
"TIMEO DANAOS ET DONA FERENTES."

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The shortage in the supply of nearly all classes of coal is as pronounced as ever. Appeals to the miners to increase outputs do not prove very effective. Business on private account is, therefore, almost infinitesimal. Attention is drawn to the fact that on the Tyne ordinary trading is being allowed on a fairly substantial scale, and that on current transactions with neutrals, prices are being realised which are nearly double those scheduled in the Coal Controllers' directions. There are on the Cardiff market inquiries for one or two neutral destinations, but merchants are unable to obtain any guarantee that coals sold by them will be released, and there is no immediate prospect of improvement in this respect. Pitwood supplies are abundant, and there is no complaint from the iron works of any scarcity in the supply of iron ore, of which, by the way, increasing quantities are being obtained from native sources.

Newport.—There is now an appreciable improvement in the situation in the Monmouthshire coalfield, and the pits are kept going to their fullest extent, both in the Eastern and Western Valleys. At the beginning of the week a little more coal was standing on the sidings than has recently been the case, but the stocks were quickly depleted, and collieries continue to find it very difficult to cope with the demand. The work of distributing coal for inland consumption is a source of constant trouble to the District Coal and Coke Supplies Committee, but all the most urgent requirements are being met with the greatest possible measure of despatch.

Miners' Wages and Outputs.—A series of statistical tables and diagrams, which have just been issued by the Statistical Department of the Monmouthshire and South Wales Coalowners' Association, throw an interesting light on the course of wages and production of coal in the South Wales coalfield. The fact seems to be clearly established that there are close inter-relations between the wages earned by the miners and the quantity of coal produced per person employed underground. Indeed, the fundamental principle established by these tables is that the higher the wage, the lower the output, and, conversely, the lower the wage, the higher the output. The year 1899, for example, was a year of low wages. In that year, the average output per person employed in the United Kingdom was 381 tons. The year 1901 was one of high wages, and in that year the average output declined to 340 tons. The general wage rate in the South Wales coalfield in 1899 stood at 23·95 per cent. on the standard rates of 1879, and with the general wage rate at that low level, the average output per person employed underground was 356 tons. Two years later, on a general wage rate of 73·33 per cent., the output per person employed underground declined to 307 tons. The same feature characterises the returns for the present war period. Thus, in 1915, when the general wage rate stood at 78·05 per cent. on the standard rates of 1879, the output per person was 297 tons, while in 1917, with a general wage rate of 133½ per cent. the output fell to 262 tons. It is therefore, pointed out in connection with the miners' new wage demand, that high wages become an evil when they have a prejudicial effect on output; and, of course, the main need of the country now is for more and more coal.

Arrears of Contract.—Colliery salesmen received communications yesterday from the Controller's Coal Contract Arrears Committee, informing them of the decisions of the Committee with regard to the cancellation or otherwise of the contracts entered into prior to May, 1917. In his instructions of July last, the Coal Controller informed them to take into consideration the following circumstances:—(1) Whether the coal was already sold abroad (or, in the case of bunkers, to shipowners) prior to June 29, and there was an obligation in the contract to deliver; (2) Whether arrears were due to colliery owners' fault or arrangements with colliery owners; (3) Whether any deliveries were made during the three months ended June 29, 1917; and (4) Whether the purchaser, while failing to take delivery, had bought improperly elsewhere. The Controller did not question the right of the purchaser to the delivery of arrears in the first two cases, but the others were to be decided on their merits, and in September he issued supplementary instructions for the consideration of these latter cases. In the decisions announced yesterday the Committee have cancelled arrears in a number of cases; they have permitted them in others; and in a few cases have asked to be supplied with the contracts themselves before giving their decision.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In the steel trade, matters stand much as they did a week ago—if anything, the pressure is easier, and manufacturers have been better able to meet the demands made upon them. Although, of course, brisk business still rules, fresh contracts would now be willingly undertaken at many of the steel-making establishments in the West of Scotland. One factor which has contributed to this state of affairs is that the shipbuilding material required in connection with the construction of the standard vessels, authorised by the Shipping Controller for the mercantile trade, has been so well pushed forward that the output of tonnage has been considerably increased. All being well, the chances are that, very shortly, there will be made heavy demands upon shipbuilders, who, in turn, will rely greatly upon steel makers for a speedy and constant supply of the required quantities of steel. When this comes along, there is every reason to believe that the activity will continue for some considerable time. At the moment, finished and semi-finished material is in great request—sectional material ship and boiler plates being most important. Export is still a very minor quantity, being represented mainly by some small shipments to the French Government and the Indian State Railways.

Malleable Iron Trade.—Both in their iron and steel departments, malleable-iron makers are as busy as it is possible for them to be, and the pressure for delivery is intense. Work of national importance has first claim, so that the entire output is practically absorbed by consumers engaged on official contracts, the larger sections being greatly in demand. With the exception of a few odd lots being despatched to the Allied Governments, export business is meantime a "dead letter."

Scotch Pig-iron Trade.—Ceaseless activity continues to dominate the pig-iron industry, indeed, this, naturally, prevents the accumulation of any stock, and consumers have to be content with the supplies meted out to them. As in the sister industries, export is decidedly off, with the single exception of Government work overseas. No change in price has, as yet, taken place.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Cutlery Trade and Recruiting.—The cutlery trade will be appreciably affected by the latest schedule of trades to release more men for the Army. All Grade I. men are to be called up, if born in or after 1883, in the case of foremen, or in or after 1880, in the case of forgers, grinders, cutlers, scissor setters, hafters and razor whetters-off. The other Grade I. men in the trade will be called up if born in or after 1875.

Manufacture of Small Tools.—General dissatisfaction has been occasioned in commercial circles in Sheffield by the order recently issued by the Ministry of Munitions prohibiting the manufacture of small tools without a license. The new order gives to the term "small tools" such a broad meaning, that its effect in Sheffield would be pretty widespread; and general objection has been raised against the circumstantial data which are required from every firm before the necessary permit to manufacture can be obtained. An application for a license must be accompanied by voluminous details relating to trade during the past six years. So great is the local opposition to the new regulation, that although the order actually came into force a week last Saturday, manufacturers are proceeding as though it were non-existent, and active steps are being taken to have the order withdrawn, or to have its requirements very substantially modified. The matter was before the Sheffield Chamber of Commerce on Monday evening, and it was clear that they considered the requirements of the order were of a most inquisitorial nature, and would involve a great expenditure of time by accountants in order to produce the particulars demanded. The Chamber have written to the Associated Chambers of Commerce, asking them strongly to protest against the introduction of the order. Manufacturers have asked the Ministry to receive a deputation on the matter, and they have informed the Department that they are not prepared to work under the new order. Up to the time of writing, however, their request for an interview had met with no response. In local manufacturing circles, bitter complaint is made that instead of the trade being first approached, the Ministry, without any preliminary whatever, simply launched the scheme upon them on the day it was to come into operation.

Iron and Steel.—For sometime now, the conditions in the steel trade generally have been tending towards an easier state of things. At present one cannot describe the heavier departments as being slack, although they are much less busy than they have been in earlier months; but in the lighter section of the trade, there is a marked quietness prevailing. For a considerable period the openhearth plant has been persistently augmented, and now, orders are being executed with much greater celerity than was the case in meeting the heavy requirements which have been called for during the past two years. Indeed, it would seem that makers have been so fully employing their resources that they have not only put themselves in a position readily to supply current needs, but also to create the establishment of a reserve of stocks, which should be equal to the biggest emergency which the next few months might bring. The placing on the market of considerable quantities of steel originally meant for Russia, is reacting upon the production of crucible steel, and there is a prospect of easy conditions remaining in this class of trade for some time. Rolling mills and forges are all busily occupied. The supply of scrap is somewhat unsettled. Some descriptions are easily obtainable, while others are decidedly scarce. The shortage of foundry iron has caused a run on good cast-iron scrap; and there is a capital market for all the good heavy steel scrap coming forward. Tool shops are working to the utmost of their capacity, and there is also great activity in the manufacture of files and circular saws, there being a marked demand for the latter from Colonial markets for wood-cutting purposes.

South Yorkshire Coal Trade.—Except that it is more difficult than ever to obtain deliveries, the general situation has not changed. The reduced output is nothing like commensurate with the demands, and even though the bulk of it is fastened up under contract account, supplies are quite unequal to the requirements. The demand for best steams among all classes of consumers remains very high; shipping calls have increased a little. Cobbles, nuts and slacks, are coming forward very tardily, and are all ear-marked for contractors. There is a lively request for gas fuels for works. The demand in the household coal trade is great, and merchants complain of a general shortage. All classes of coke are bringing maximum prices. Nominal prices at the pit are as follow:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.* per ton at the pit.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Much firmness continues to characterise the pig-iron market, and with facilities for delivery still improving, June distribution by rail promises to be the heaviest of any month this year; whilst, as more tonnage is available, shipments are larger. Home demand for foundry iron is heavy and continuous, all the northern foundries being very busily engaged. There are still very good inquiries for forge quality, both on early and forward account, but pressure for delivery is not so urgent, recent supplies having been on a scale sufficient to enable consumers to accumulate a little stock. Exports both to France and Italy are reported. For home consumption, No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge, all stand at 95*s.*; and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are all quoted 114*s.*; and No. 1 is 119*s.*

Hematite Iron.—It is gratifying to know that production of hematite is sufficient to permit shipment of a few parcels to the Allies without stinting home consumers, and advantage has been taken of the improved tonnage situation to meet the pressing needs abroad. Nos. 1, 2 and 3 East Coast brands are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are working at very high pressure to cope with the huge demand, and the enormous output is insufficient fully to meet requirements, but it is gratifying to have the assurance that not only are wants of shipbuilders receiving adequate attention, but that producers have work for the shipyards well in hand. Values of all descriptions are very strong. For home consumption, common iron bars are 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; double best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Export prices are not fixed, but they may be given approximately at 2*l.* to 3*l.* per ton above home quotations.

Ironworkers' Wages.—The secretaries to the Board of Conciliation and Arbitration for the manufactured iron and steel trade of the North of England report that for the two months ended April 30 last, the average net selling price of iron bars and angles was 14*l.* 1*s.* 9*d*·54, as compared with 13*l.* 16*s.* 7·64*d.* for the previous two months, and that this carries an advance of 3*d.* per ton on puddling, and 2½ per cent. on all other forge and mill wages, to take effect from the 27th ultimo. They state that, in accordance with the Ministry of Munitions lines of settlement of January 3 last, and February 20 last, this advance will merge into the 12½ per cent. bonus, and the 7½ per cent. bonus granted under those settlements.

Coke.—Coke is scarce, and shipments to neutrals restricted. Heavy local requirements continue to be moderately well met under the conditions prevailing, but some consumers complain of inadequate supplies. For shipment to neutrals both foundry and furnace coke range from 50*s.* to 55*s.* and even more. For home use, foundry coke is 38*s.*; average blast furnace kind, 33*s.* at the ovens; and quality low in phosphorus, 35*s.* 6*d.* at the ovens. A new battery of coke ovens is being installed at the Acklam Ironworks, Middlesbrough.

THE GALL INGLIS RECKONERS.—Mr. J. Gall Inglis has compiled three "Presto" reckoners, one being a 12½ per cent. and one a 7½ per cent. bonus and percentage card, both rising by pence from 1d. to £8; the third is a shift and hours worked time-calculating card for time-keepers, costing clerks, &c., showing the interval between two times—6 a.m. to 10 p.m. The three reckoners are issued at the price of 2*s.* each net by Messrs. Gall and Inglis, 31, Henrietta Street, W.C., and Edinburgh.

NOTICES OF MEETINGS.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 19, at 5 p.m., at 70, Victoria-street, Westminster. Papers to be read:—1 "The Lunar Atmospheric Tide at Greenwich, 1854–1917," by Mr. S. Chapman, M.A., D.Sc.; 2. "On the Audibility of the Gunfire on the Continent at Chignal St. James, near Chelmsford, during 1917," by Mr. Miller Christy, F.L.S.; 3. "Seasonal Variation in the Audibility of Distant Gunfire," by Mr. F. J. W. Whipple, M.A., F.R.Met.Soc.

THE ROYAL SOCIETY OF ARTS.—Thursday, June 20, at 4.30 p.m. "Indian Cotton and the Cotton-Mill Industry," by the Hon. Sir Dinshaw E. Wacha. The paper will be read by Sir Charles H. Armstrong. Chairman, the Right Hon. E. S. Montagu, M.P., Secretary of State for India.

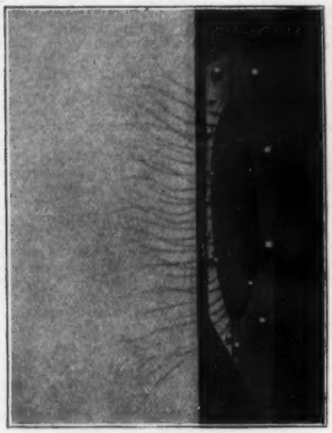
TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a new list (No. 56) of additions to the Statutory List of firms of enemy nationality, or enemy association, with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

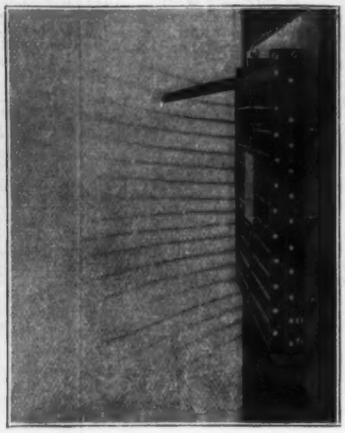
MEGAPHONES WITH RECTANGULAR APERTURES.—The theory of horns in which sound waves travel through slit apertures was given by Rayleigh. When the width of the slit is large by comparison with the length of half a wave, the waves of a train of sound waves, passing through the slit, spread out little and proceed almost undisturbed. When the slit width is smaller than the length of half a wave, or equal to it, the waves spread out as if they came from the aperture itself. Upon this consideration Rayleigh based his horn with elliptical aperture. The major axis of the ellipse was made larger, the minor axis smaller than the half-wave length. When the major axis was held vertical the axis of the horn itself being horizontal, the sound spread out in a horizontal fan. Rayleigh also experimented with horns of rectangular apertures for studying these phenomena. This line of study has been taken up by Professor F. R. Watson, of the University of Illinois, who presented a paper on the subject, with special reference to speech, to the American Physical Society last December. He constructed several megaphones with rectangular apertures. Holding the horn horizontally with the rectangular aperture vertical, he observed that the sound spread sideways in the open field, and that people even 90 deg. off the direction of speech could hear. When, however, the slit—*i.e.*, the long edge of the aperture—was horizontal, people standing by the side might hear the noise but could not understand. The observation is interesting also for phonograph signalling, and it suggests some conclusions as to the wave-length of speech as the words were diffracted by the narrow dimension of the rectangular aperture, but not by the wide dimension. Some components of speech must have half a wave-length intermediate between these two limits.

THE GERMAN COMPANY FOR ELECTRICAL UNDERTAKINGS.—This company states in its report for 1917, that the electricity supplying industry during last year suffered heavily from the prevailing conditions. A number of the leading concerns in this branch, owing to diminished surpluses, have had to reduce their dividends, and the end of this retrogressive movement is not yet in view. Existing contracts, mostly dating from the time before the war, with unaltered tariffs and other conditions, did not allow of charging suitable prices for electric energy. A number of municipalities and other large consumers had certainly agreed to modified tariffs and other improvements in the contracts from the generating company's point of view, but most customers preferred to hold to their advantageous old contracts. The Company for Electrical Undertakings considered it necessary that the German Empire should bring about a legislative regulation of these matters, so that the tariffs might be altered according to the increased cost of production resulting from the war. Steps in this direction were being taken. The company had experienced a set-off against the decreased revenue of the generating works by an improvement in the traffic of the tramway companies in which it was interested, also by its share in the Bologna electricity works, and from the greater portion of its shares in the Company for Electric Means of Communication in Budapest having been favourably disposed of. The greater portion of the profits has apparently been applied to reserves, the net profits amounting to 3,715,232 marks against 3,719,224 marks for the previous year, of which the dividend on the share capital of 60,000,000 marks absorbed the bulk. With regard to the foreign undertakings of the company, it was stated that the Société Financière de Transport et d'Entreprise Industrielles, Brussels, again paid a dividend of 7 per cent. The power station construction for the overland control at Warsaw was still left in abeyance. The Tramways et Electricité Company, Constantinople, had certainly again had good receipts, but the result suffered from the much increased prices for materials, &c. The company's holdings of shares, &c., amounted at the end of 1917 to 105,059,003 marks against 109,771,059 marks at the end of 1916. The company, in the course of the year, in addition to the shares already referred to, having also disposed of shares in the Stuttgart Tramways and the Frankfort Local Railways Company. New shares had been acquired in the Leipsic Overland Power Station, and in the Budapest Company for Electric Undertakings. Shares in the Knorr Brake Company for 2,750,000 marks were also a new acquisition.

THE AIR SUPPLY TO BOILER ROOMS.

(*For Description, see Page* 662.)





FIGS. 19 AND 20. AIR FLOW AT FAN INLET. (EXPOSURE, 2½ MIN.).

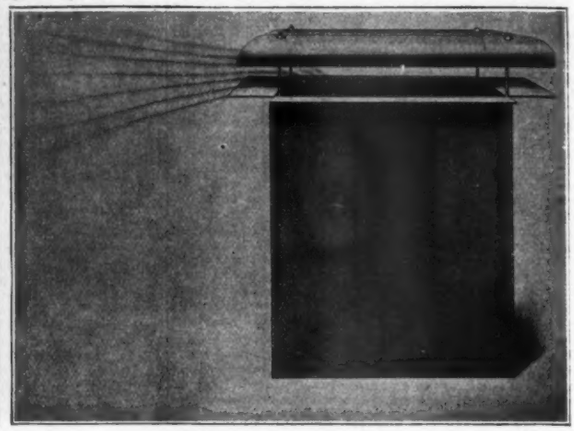
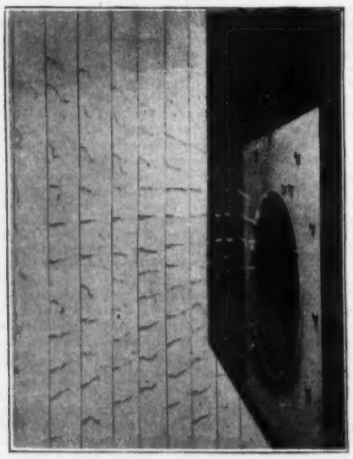
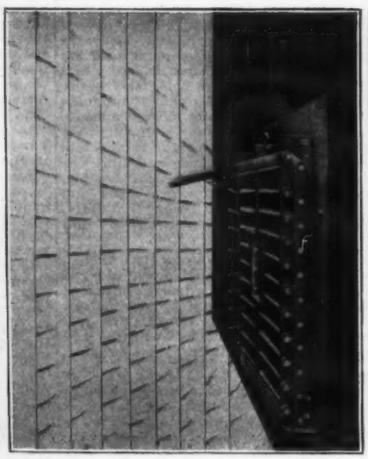


FIG. 23. INTAKE.





FIGS. 21 AND 22. AIR FLOW AT FAN INLET. (EXPOSURE = $\frac{1}{250}$ SEC.).

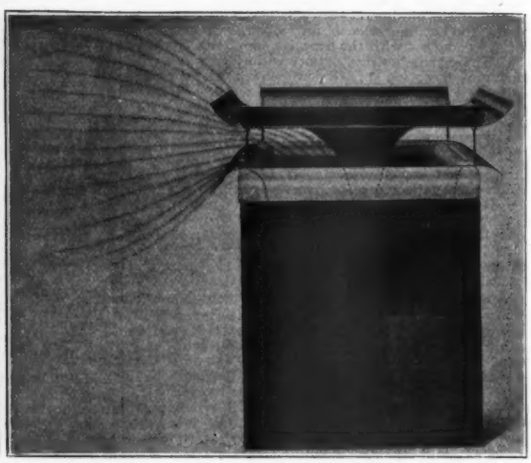
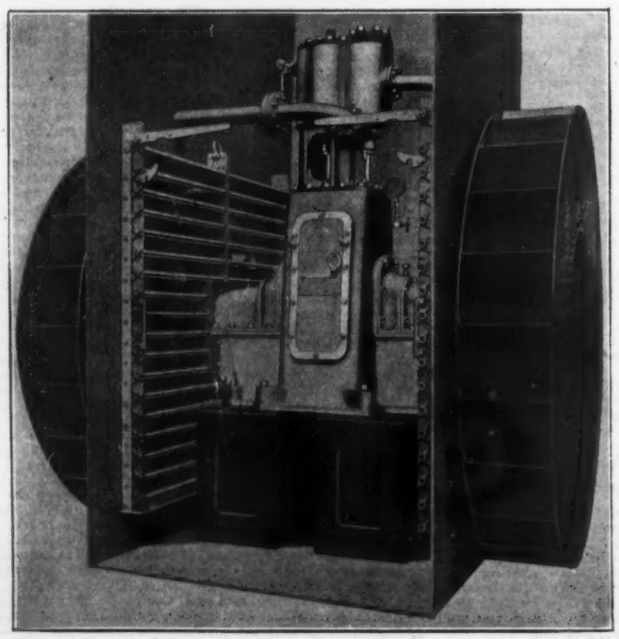
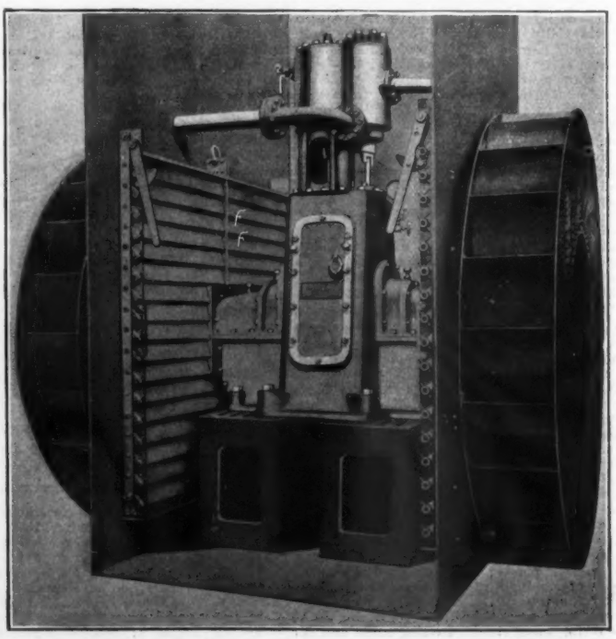


FIG. 24. AIR FLOW THROUGH WEATHER-FLAPS AT INTAKE.





FIGS. 25 AND 26. STREAM-LINE SHUTTERS, FITTED TO FAN INLETS OF DOUBLE-ENDED SETS. END WALL OF COMPARTMENT REMOVED.

1,200-B.H.P. TWIN DIESEL MARINE ENGINES.

CONSTRUCTED BY THE NEDERLANDSCHE FABRIEK VAN WERKTUIGEN EN SPOORWEGMATERIEEL, AMSTERDAM.

(*For Description, see Page* 658.)

Fig. 8.

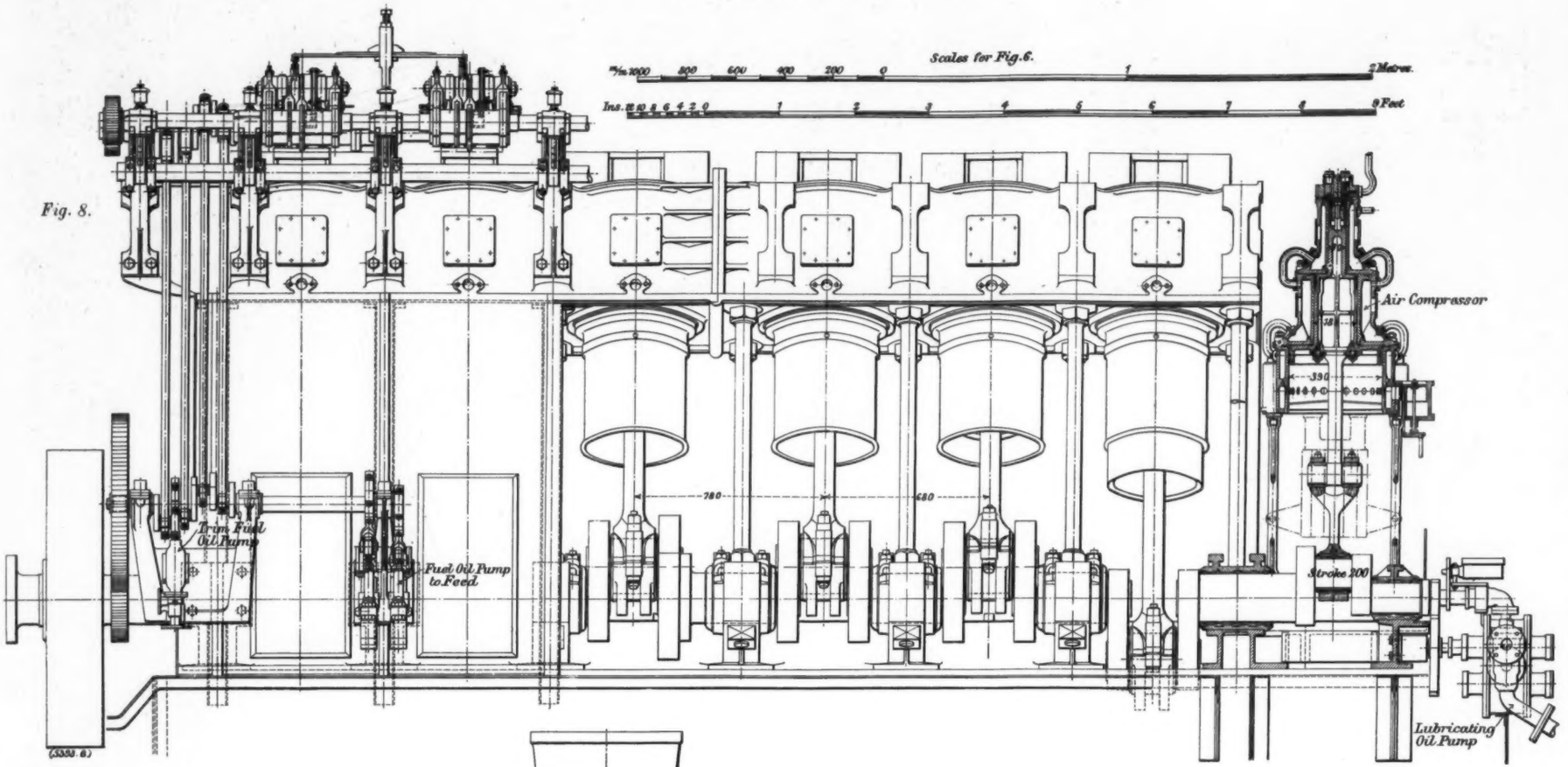


Fig. 9.

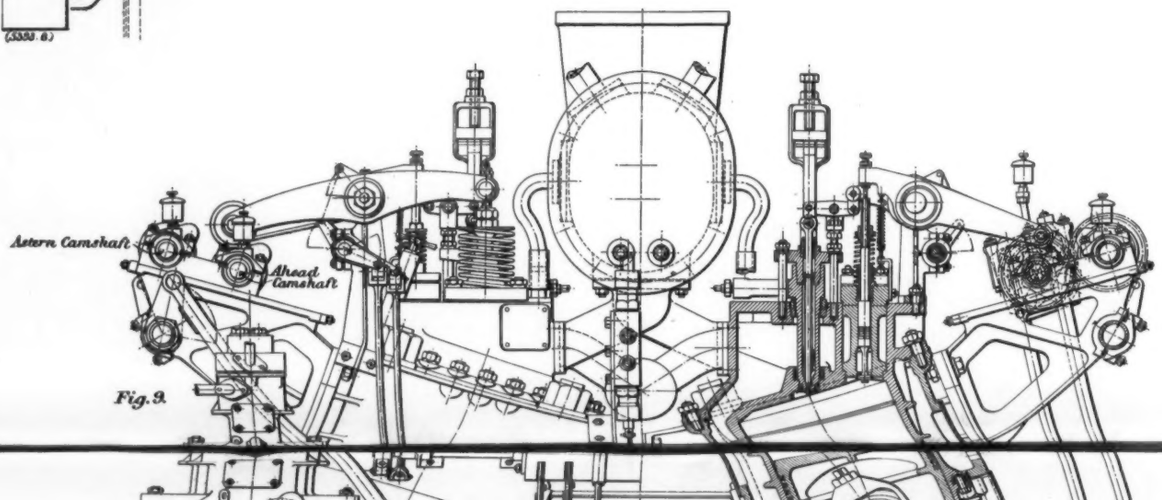
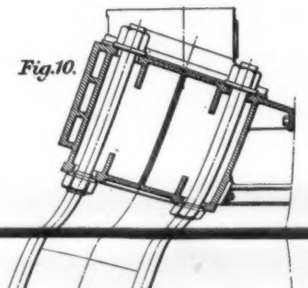
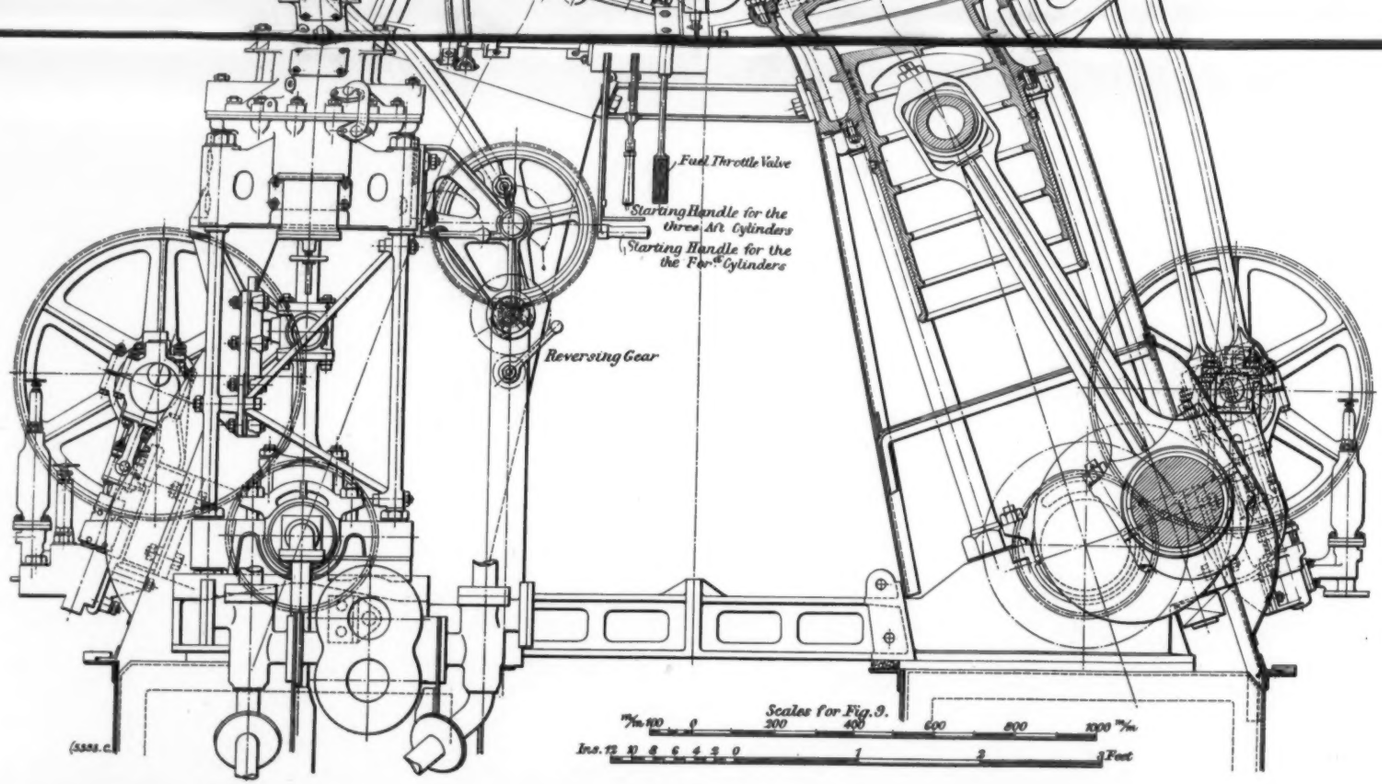
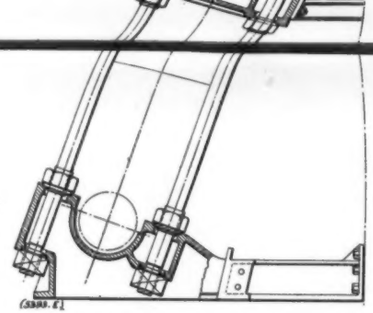
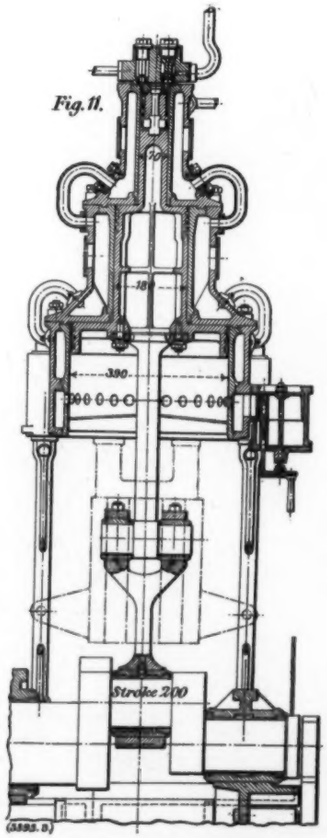


Fig. 10.









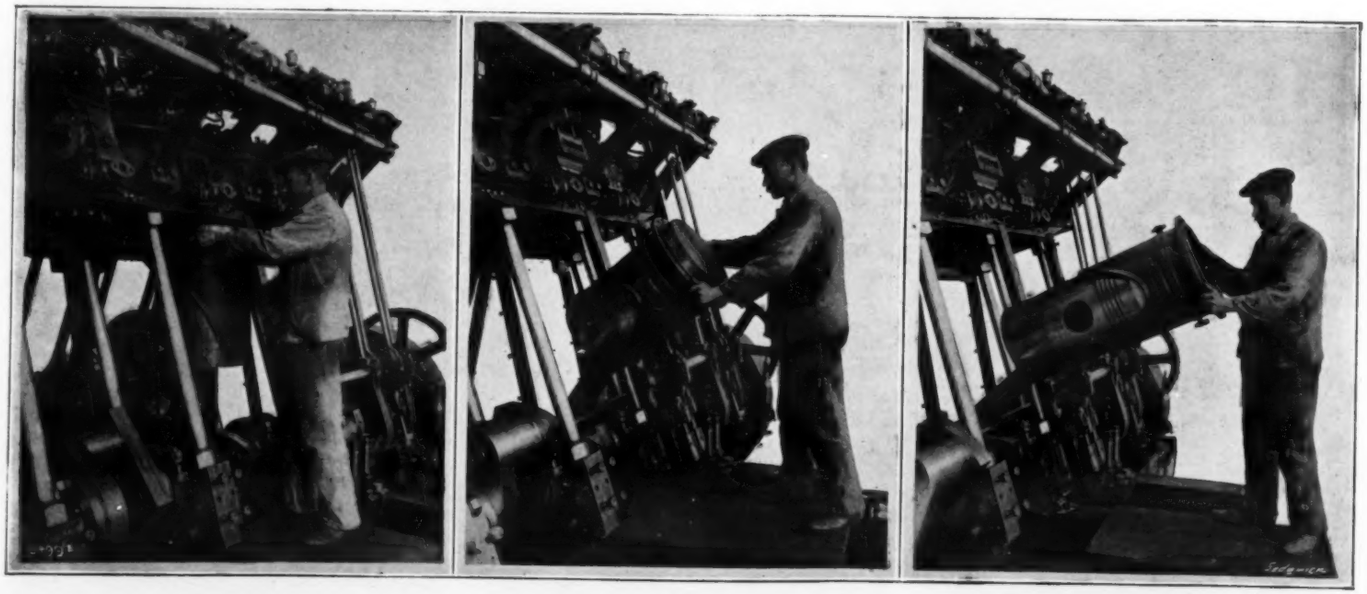


Fig. 12.

Fig. 13.

Fig. 14.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 3d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 667.

ENGINEERING.

FRIDAY, JUNE 14, 1918.

DILUTION OF LABOUR.

IN common with all the other schemes and expedients devised during the period of the war, the success or failure of the scheme of dilution of labour must be judged by the extent to which it has contributed to the provision of an adequate supply of all the essential munitions of war. Judged by this fundamental standard, the results already achieved are such that the success of the scheme of dilution, regarded as a whole, must be readily admitted by all unprejudiced critics.

The degree of success which has attended the application of the scheme of dilution to the manufacture of shells has recently been emphasised by the announcement of the dismissal of many thousands of women workers from establishments devoted to the production of shells, and staffed almost entirely by women. That it should be found possible to dispense with the services of so many dilutees at the present crisis of the war is significant of the success which has attended the efforts of these workers in a sphere which until recently was considered the preserve of the skilled engineer, while the direct result of this success in freeing very large numbers of trained engineers for work of a more skilled nature has been of inestimable value to the nation. Bearing in mind the value of the work accomplished by the introduction of female and unskilled male labour in the production of this class of munitions of war, it may be of interest to inquire whether full advantage has been taken of dilution of labour in other equally important departments of war effort, and to examine the degree of success achieved.

At the present time, no industry is of more vital consequence to the nation and to the Allied Powers than shipbuilding and marine engineering, and while great and increasing assistance in the production of ships and machinery is being given by America, it is to the output of our own yards and engine shops that we must look for the immediate increase in the output of new tonnage which is so vitally necessary. The output of new ships for April is given as 111,533 tons, or less than half our average monthly losses by submarine action, and the question naturally arises whether the principle of dilution of labour, which has proved so successful in the manufacture of shells, has been given an equal chance to prove its worth in the shipyards and engine shops. In the first place, it must be clearly understood that the conditions of work in a general engineering shop are entirely different from those which obtain in a shop devoted exclusively to the production of one standard article, such as shells, while the conditions of work in a shipyard are in no sense comparable to those in an engineering shop. In the case of the shop devoted entirely to the production of a standard article, the conditions are practically ideal for the rapid training of female or unskilled labour to a degree sufficient to ensure the satisfactory performance of duties which must, of necessity, become largely mechanical through constant repetition. The general engineering shop presents a much more complicated problem, for in this case, the volume of repetition work is very largely reduced, the variety and difficulty of hand and machine operations greatly increased, and, consequently, the general level of skill required of the worker is higher, and the proportion of unskilled labour which can be profitably and usefully employed is, therefore, less.

In spite of this handicap, the employment of women in general engineering shops has, on the whole, made very satisfactory progress, both as regards numbers employed and quality of output. Past and present experience with skilled male workers leads to the conclusion that a uniform degree of success from the employment of diluted labour is not to be looked for, and the facts are in accordance with this conclusion. Adverse reports on the utility of female labour are by no means uncommon among practical men, and are not all without foundation. At the same time, it is impossible to overlook the significant fact that for one failure it is generally possible to point to several cases of successful performance of the same job with similar labour. That there is still a considerable body of opinion on the part of employers, foremen and men, hostile to the training and employment of women, is undoubtedly true, and under such conditions success is impossible. Attempts have been made to ensure the employment of unskilled labour in the manufacture of shells by the insertion of a clause in the agreement stipulating that a large and definite proportion of the factory operatives shall be women or unskilled men. This fixing of the extent to which diluted labour must be employed has not yet been applied to general engineering shops or to shipyards, but there does not seem to be any good reason why a scheme on generally similar lines should not be applied to these works. At the same time, it is most essential that the employment of women should be so regulated that no foremen can say with truth that he neither requires nor desires the women workers whom he is compelled to employ in order to satisfy Government officials that the principle of dilution is in operation in the works. Neither is it in any way to the advantage of industry, or of the nation, to dispense with the services of old men as sweepers and cleaners in order to replace them with twice or three times the number of lusty young women, as is too frequently done, simply in order to show a good proportion of women workers. At the present time general engineering works are employing women with success on the following, among other jobs:—Crane driving, lathe operations of various kinds, drilling, milling, slotting and planing; straightening and cutting tubes for condensers, turbine blade fixing, filing and chipping, assembling and erection of valves, &c. The scraping up of cast-iron joints, &c., also preparing and fitting up valves, pipes, &c., for water testing could largely be done by woman labour.

In shipbuilding operations the employment of women has been much less systematically developed, though there are a number of yards which have made commendable progress with the scheme. The working conditions in most shipbuilding operations are against the employment of women for the following reasons: (*a*) Heavy nature of work; (*b*) exposure to weather; (*c*) dangerous conditions under which much work has to be performed. Shipbuilding operations, naturally, group themselves into two main classes, viz.: (1) Preparation of material on the ground, previous and preparatory to erection on building blocks; and (2) erection and fixing of all material in position on blocks preparatory to the launch and fitting out after the launch. Of these, the modern tendency is to develop (1) to the utmost limit—as in "fabricated" ships—so that this section of work is of very great and increasing importance. To much of the work in this section, female labour has already been successfully applied—the fact that such work is performed on the ground and in many cases under cover, being of great advantage in this connection. On board the ships, during the early stages of construction, conditions are not at all suitable to the

employment of women, owing to the heavy nature of the work, and the insecure footing provided. With the advancement of building operations, the conditions become more suitable, but the question of efficient supervision becomes more difficult.

The shortage of men, and thus the need for increased dilution of labour, is most pronounced in the iron trades, and it, therefore, becomes a question of importance how far the principle can be applied to these trades. The shortage is probably most marked in the riveting trade, and no real effort seems to have been made to remedy this shortage. The arduous nature of much of the riveters' work makes it unsuitable for the employment of women, except in the case of hydraulic riveting, and such forms of pneumatic riveting as are performed with fixed machines. Both these forms of riveting have been successfully performed by women, but the practice is by no means as general as it might be. Hand and pneumatic forges and oil fuel furnaces for heating rivets, where these are operated on the ground, or on a suitable and safe platform, could all be worked by women, and thereby a good proportion of rivet boys would be set free to commence riveting. The principle of dilution could, with advantage, be applied in an extension of pneumatic riveting. America is solving the difficulty of shortage of riveters with characteristic directness by training clerks, labourers, professional men and many others to use the pneumatic hammer. Practically no such effort has been made in this direction in Britain although there are still large numbers of men less usefully employed.

The caulking trade could well be assisted by women on such work as packing plates and angles before riveting, tapping small diameter holes, cutting large diameter holes by machine, attending water squads, cutting by the oxy-acetelyne process, &c. The platers' shed contains a number of machines which could well be worked by women, *e.g.*, drilling, countersinking, saw, plate mangle and buffing wheels. Driving of overhead and other cranes has already been satisfactorily done by women. The drilling department could well employ women for the operation of light electric boring machines, both on the ground and on board ship, while the same may be said for the lighter forms of pneumatic drills and reamers now so commonly used. In the joiners' shop, electrical shop and plumbers' shop, the operation of nearly all the machines is easily within the capabilities of women of the class who have done so well on munition and general engineering work, while the employment of women for running and clipping electric cables on board ship, painting and red leading, cutting and laying deck coverings, such as linoleum, and many other light jobs, is not only feasible, but should be insisted on in the interests of the man power of the country. Timekeeping and checking for all departments could well be undertaken by women or by disabled soldiers, yet many able-bodied men remain in this class of work. The possibilities of the temporary transfer of workers of one trade temporarily slack to assist a trade suffering from a shortage of labour have not been utilised to anything like their full value, and the blame for this rests largely with the trades unions concerned. The position of our shipyards as regards man power is in many cases very far from satisfactory, and in view of the possible calling up of some of the younger men, it becomes the imperative duty of the Government Department concerned, the employers, the trades unions, and the workers to combine to make the employment of women and unskilled labour in the shipyards no less successful than it has proved in the munition works.

THE ROMANCE OF PETROLEUM.

WE are not sure in which aspects of petroleum and its industry Sir Boverton Redwood, Bart., D.Sc., found romantic elements when he discoursed, last Friday, on the "Romance of Petroleum" at the Royal Institution. He did not refer to the manifold comforts, blessings and curses, civilisation owes to that industry, except perhaps in his concluding allusion to the disabilities imposed upon him by the Official Secrets Act, and the stringent regulations of the Defence of the Realm Act and of the Censor. Pouchet's familiar imaginary views, which Sir Boverton showed, of landscapes from the carboniferous period, when dense, sad, silent forests and herbaceous aquatic plants covered the earth from pole to pole, and from the tertiary period, when the formation of our big natural stores of petroleum was possibly completed, were merely fanciful, not romantic, while the story of the discovery and acquisition of the Anglo-Persian Oil-field by Mr. Knox d'Arcy and the Government, upon which Sir Boverton dwelt at length, indicated shrewd, patriotic business sense rather than romance. There is more romance in the discovery of Thomas Young that paraffin and lubricating oils and wax could be obtained from bituminous coal by gently heating the coal. Out of that observation of 1850, which followed the exhaustion of the oil stream that had been flowing from the Alfreton coal-working in Derbyshire, grew the Scottish shale industry, and an oil fever—though far milder than the oil-fever of the United States—during which a poacher discovered shale oil near Tarbrax; this shale was later worked by the Caledonian Oil Company, as Sir Boverton related.

The romance may chiefly be found, perhaps, in the gigantic scale on which everything connected with petroleum and its industry is being done, in its power for good and evil, and in the reckless haste with which petroleum is being extracted and—unintentionally—wasted. Yet Nature, in manufacturing petroleum, need never to have worked at a more rapid rate than that in which it is producing oil at present—in a sense, on a small scale—near Karabugas Bay, on the eastern shores of the Caspian Sea. Into this land-locked bay organic matter is constantly being conveyed from the open sea through a very shallow entrance over the bar; the broiling sun evaporates the water, already highly saline, salt and Glauber's-salt are being deposited, all marine life is killed and putrefaction prevented, and the oily products of a very slow distillation of the organisms accumulate. Other conditions may elsewhere be favourable to slow distillation of organic remains, and the mosses and small ferns of the carboniferous period probably had more to do with the origin of petroleum—and of coal as well—than the great tree ferns of those ages. The view that decomposed metallic carbides gave rise to the production of petroleum, now finds few supporters. The organic origin is generally conceded, and both plants and animals may have contributed their share in sufficient variety to account for the different types of petroleum; scientifically, it must be borne in mind, the term petroleum comprises all natural oils and shale oils, bituminous substances, pitch and ozokerite, as well as natural gas.

Petroliferous strata occur all over the world probably, by preference along the faults of great mountain ranges, and in all geological periods, though chiefly in the carboniferous and tertiary; in the latter, petroliferous formation may, Sir B. Redwood suggested, be coeval with the advent of man. The world's petroleum output of 1917 is estimated at 70,403,128 metric tons. Of this, the United States produced 64·74 per cent., Russia, 3·26 per cent., Mexico 11·37 per cent., the Dutch East Indies 2·74 per cent., Roumania 2·08 per cent., and all the parts of the British Empire together 2 per cent., India and Burmah ranking first with 1·61 per cent. To store that bulk of oil would require a cylindrical tank, 30 ft. high, 2 miles (10,952 ft.) in diameter, covering three times the joint areas of Hyde Park and Kensington Gardens; seven million 10-ton tank-wagons, making a train 28,000 miles long (the length of the equator is 25,000 miles) would be wanted for the transport of the oil; and a pipe line, 6 ft. 2 in. in diameter, would take a year to deliver the oil at a rate of flow of 3 feet a second. In the actual steel pipe trunk lines, 8 in. in diameter, of which thousands of miles have been laid down in the United States, the pressure may rise to 1,200 lb. and even 1,500 lb. per square inch, and the gas pressure, under which the oil is forced out from the wells, frequently amounts to several hundred pounds per square inch. That accounts for the enormous unintentional waste. The Grosni well in the Northern Caucasus threw up 18,500 tons of oil per day during the first three days of its outburst in 1895; the rush quickly destroyed the derrick, and the first dam, hastily erected to create a reservoir for the oil, soon broke down and had to be supplemented by two further dams. More violent and disastrous still was the outburst from the San Diego oilfields of Messrs. Pearson in Mexico in 1908. Oil was struck there at a depth of 1,824 ft. on the morning of July 5; within 20 minutes the ground began to tremble, and earth-fissures formed to distances of 250 ft.; one of these extended under the boiler-house, the gas and oil caught fire, a flame shot up 1,460 ft., enabling people 11 miles away to read at night time, and some 3,000,000 barrels of oil were burnt by the time the fire was extinguished on August 31, by means of sand. The amount of water and solid matter carried away by the rush was much vaster still than the oil flow.

Oil engineers have always to be prepared to face difficulties of this kind in oilfields. Before they had learnt to secure and to utilise the natural gas, the railway tracks of the oilfields of Western Pennsylvania were lined with vertical steel pipes serving as gas outlets and as burners for the natural gas which roared away day and night in the early 'eighties. The sight might have fascinated the fire worshippers of ancient times who gathered at Baku, possibly long before anybody thought of utilising the oil and gas exuding from the ground. The natural gas of Pennsylvania, it may be remembered, transformed Pittsburgh, which in the early 'eighties still enjoyed the reputation of being the dirtiest—or at least the dustiest—city of the United States, into one of the cleanest cities. The coal dust disappeared when the furnaces and works were fed with natural gas. The new fuel and illuminant resented being harnessed, and as the gas did not, as a rule, betray its presence by smell before exploding, ungrateful humanity called it treacherous. Sodom and Gomorrha may not have much physical warning of their doom either; Mr. W. H. Dalton has suggested that the two towns were destroyed by an outburst of petroleum—helped or caused, one might feel inclined to add, by an earthquake. What petroleum products can accomplish in explosive force and poisonous vapours, even those who have kept at a safe distance from the "front," know sufficiently well by this time. Oil diggers cannot help feeling that the original petroleum, liquid-gases and vapours, are poisonous and dangerous enough in themselves to destroy all romance. Sir Boverton exhibited a photograph of a pitiable scene from the Burmah oilfields, dating from the days of King Theebaw, that is, also from the early 'eighties, probably. There hand-dug wells were being sunk to depths of 300 ft., and young strong men could not bear working in these wells for more than 5 minutes; the photograph showed one man just brought up from the well in a state of utter exhaustion, and another, with his eyes bandaged to accustom him to the darkness below, ready to descend.

Such primitive methods of oil-producing had been in use for centuries in other parts of the world. If they had not been replaced by modern machinery, percussion drills and rotary drills, 20 in. in diameter, driven by the power of the very oil they help to raise, and capable of sinking wells to depths of a mile and more (5,810 ft. at Boryslaw-Tarnowice, in Galicia), and if oil transport by bullock wagon, camel and sailing boats had not been superseded by pipe lines, tank wagons and tank steamers, the modern romance of petroleum might still be in store for us. In a certain sense the romance of petroleum is the romance of coal. The potencies of coal are intensified in petroleum, for good and for evil. Time, pressure and heat may, to all appearance, transform the same organic matter, which under certain conditions yields coal, into petroleum, and either keep the products together, or separate them from one another. But the romance of flying, on wheels along roads, and on wings high in the air, is the real romance of petroleum and petrol, though coal alone might have enabled us to reach the same goal at a less revolutionary pace. The spirit of our age is the petrol spirit. It has freed us as a race from the accusation of decadence. Our young men all crowd into the air service, and when there they perform feats of heroism which will easily bear comparison with those of the heroes of antiquity. Even in the

stirring time of the last four years, among all the romantic incidents which have been related, and those more numerous that have escaped recital, the deeds of the airmen stand pre-eminent.

BRITISH DYES, LIMITED.

IN the course of a former article* we referred, on the authority of Professor Armstrong, to the firm of Simpson, Maule and Nicholson, the leading manufacturing chemists of their day, stating that their success was due to the fact that Nicholson was a very able chemist. When he retired, the firm ceased to develop. It, or its successors, we added on the same authority, still employed some very able chemists, but these had no control over the business policy, and the end was disaster. At one time, their leading chemist was Professor Meldola. When he invented his blue, the firm refused to take it up; he published an account of his discovery, with the result that it founded the fortunes of a leading German firm. The successor to Meldola was Professor Green, who invented in primulin a dye of an entirely new type. This the firm refused to patent, and within a few weeks it was, in consequence, made in Germany, the whole advantage being lost to this country. Further, it is, of course, well known that as early as 1856 W. H. Perkin, in this country, discovered a dyestuff derived from aniline.

These facts show that we were at one time in the front with reference to the manufacture of chemical dyes. Owing, however, to shortsightedness on the part of some former British firms, owing also to lack of recognition and lack of encouragement on the part of successive Governments, we lost the lead and Germany became the source from which the many products obtainable from coal tar were distributed over the whole world. Until 1914, Germany succeeded in maintaining the premier position in the chemical industry, in a great measure by discouraging through her many agents in this country the manufacture of numerous products, offering German-made similar products at cheap rates. Further, German firms never lost an opportunity of acquiring the primary raw material, coal tar, obtained in Great Britain, and one scheme of these German firms was to stipulate that the coal tar and other by-products derived from the recovery coke oven installations, the Huessener ovens among others, which the German firms put down in this country, were to be delivered to Germany over a number of years in part payment of the coke-oven installations, thus increasing the raw material supply available for the German chemical works.

One of the first results of the outbreak of hostilities between the United Kingdom and Germany was the realisation of the fact that the British textile trades were mainly dependent on the German source of supply for their colouring materials. The Government thereupon considered what steps should be taken to deal with the difficulty, and a committee representing the dye-consuming industries was appointed to consult with the Board of Trade. As a result of their deliberations, a scheme was prepared for the co-operation of the Government with the dye users. The scheme provided for the formation of a limited liability company, British Dyes, Limited, having a proportion of capital advanced by Government, the object being to re-establish—and we say re-establish advisedly—the synthetic dyestuff industry in this country. The Government agreed to advance up to 1,500,000*l.* on a mortgage debenture, and the company were authorised to raise 3,000,000*l.* ordinary share capital, to be obtained from consumers of dyestuffs. The new company proceeded to allotment on April 1, 1915, with an issue of 1,000,000 1*l.* ordinary shares.

The company availed themselves of the agreement which had been made between the Board of Trade and a dye-making works in the North of England, and acquired the undertaking of the latter, the purchase being completed in June, 1915. Since then, the company have utilised these works as a nucleus for development. They decided also to complete the extensions commenced by the former owners and, further, to erect a new factory on an extensive site in the immediate neighbourhood of the existing works. In the latter part of 1915, various estates having a total area of about 500 acres were purchased for this latter purpose. Plans were immediately prepared and contracts given out, the first sod on the new site was cut in November, 1915, and the first piece of work undertaken was the construction of a railway from the old works to the main railway system through the new site.

We had the opportunity a few days ago of visiting the company's older works and their new installation and were greatly struck with the great activity displayed in both in the manufacture of acids, "intermediate products," and all kinds of synthetic dyestuffs and other chemicals derived from the said intermediate products. Another feature which greatly appealed to us, and to which we desire to refer here before giving a very brief description of the works, was the large initiative allowed the chemists in charge of the various departments and the cordial relations existing between the directorate and the chemical staff.

The manufacture of synthetic dyestuffs may be divided into three stages, the preparation of pure raw materials, benzol, naphthalene, &c., from the crude coal-tar derivatives, followed by the preparation from the pure raw materials of a series of chemical compounds known as "intermediate products," of which there are about 100 of prime importance, and, finally, the preparation of the finished colouring matter from the intermediate products. German manufacturers had developed large plants for the manufacture of intermediate products and were in a position to offer these latter to dye manufacturers at prices which rendered their production in this country unprofitable. By holding a virtual monopoly in intermediate product manufacture Germany really controlled the dyestuff manufacturing operations of the whole world. The company, therefore, adopted the policy of developing as far as possible the manufacture of intermediate products at both their works, a scheme which met with the approval of their leading shareholders and which has succeeded so far as they have had time to extend their installations. The company now manufacture many intermediate products on a commercial scale; they have prepared plans for a further extensive programme of intermediate-product plant construction which now only awaits official sanction. In this connection it may be stated that of the expenditure required for plant for dealing with coal-tar derivatives only, about 85 per cent. is represented by the intermediate-product plant alone; the dye-making installations for converting the intermediate products into finished dyestuffs is not only less costly but is also less complicated, and the processes involved are more simple.

The intermediate products are obtained by treating with mineral acids the pure raw materials distilled from coal tar. Owing to the fact that the operations of the company were started when practically the whole of the supplies of acid in the country were required for the manufacture of munitions of war, the company had to put down their own plant for the manufacture both of oleum, or fuming sulphuric acid, and nitric acid. A considerable proportion of the former used by British dyemakers before the war came from Germany, but our development of war industries has made it certain that British dye manufacturers will in future be supplied from British sources only, and the least of these sources will not be the company's plants, judging from their capacity of production, and the stores of acid and of raw materials for its manufacture available on the company's premises.

The company's older plant, which, under the former management had acquired reputation for the manufacture of aniline dyes, among others, is self-contained, and is working to the full in the manufacture of a variety of intermediate products, finished dyes and other nitrated chemicals. Several of the installations are new, whilst others have been improved by the present owners. But owing to its situation, the older plant could not be extended to meet present-day requirements and the company acquired, as above stated 500 acres of land in close proximity, on the other side of the river, and connected this new site by a standard-gauge line with the older plant. The new works, where the manufacture of acids, intermediate products and finished dyestuffs is proceeding apace, and where further buildings are in course of completion and the construction of others are planned, give the impression of an international exhibition site, the buildings being on both sides of a main avenue 120 ft. in width and 1¼ miles in length. A standard-gauge line runs on each side of the avenue; the whole works are served by 15 miles of standard-gauge track and communicate with the London and North-Western Railway by a siding. The various buildings are each 270 ft. long, 90 ft. wide, there being provided between two consecutive structures a space of 90 ft. for future extension should the need arise.

Power is supplied to the new works by two Westinghouse turbine sets, of 2,500 kw. each direct-coupled to the generators. The turbines are constructed on the bleeder principle, steam being drawn off from them at 30 lb. per square inch, for various purposes in the works. This is very satisfactory thermodynamically, as all the heat units in the steam can be economically used. The condensers are of the plain jet type, water being taken from the local stream for cooling purposes. The putting down of a further 5,000-kw. turbine set is under consideration, in connection with a standard surface condenser and cooling towers; this new power set is urgently needed, since the load now approximating the maximum load of one machine, no spares will be available in the near future. The load factor is 80 per cent. The present steam supply is ensured by fifteen 30 ft. by 8-ft. 6-in. Lancashire boilers fitted with coking stokers, automatic-feed regulators and superheaters. The latter are provided with by-pass valves to enable saturated steam to be supplied to the gas producers. Weir steam pumps are used throughout. All coal and ash is mechanically handled. There are in course of erection six Stirling water-tube boilers, each having an actual evaporation of 25,000 lb. of water per hour at 200 lb. pressure and 200 deg. superheat. A boiler-house to contain sixteen 30-ft. by 8-ft. 6-in. Lancashire boilers is also contemplated. This installation is to generate steam at a 160 lb. pressure for use throughout the chemical plant only; the steam will have only sufficient superheat to prevent condensation in the pipes. The installation of two other similar batteries of boilers is to be proceeded with in other parts of the works. Lancashire boilers are found particularly suitable for the generation of steam for the various purposes for which it is required throughout the works. In one process alone the demand of steam may vary from nothing to 75,000 lb. per hour in 30 minutes. At the older works, the steam supply is ensured by 24 Lancashire boilers.

The plant for the supply to the works of compressed air at a 75 lb. pressure consists of three electric motor belt-driven compressors, each capable of compressing 1,000 cub. ft. of free air per minute to a pressure of 80 lb.; and two steam-driven compressors, having the same capacity as the former. The exhaust steam from the two latter sets is utilised in the gas producers.

Electric current is generated at 3,000 volts, three-phase, 50 cycles, and is transformed down to 400 volts for supply throughout the works; the motors are 400-volts, three-phase machines. Lighting is at 232 volts between phase and neutral. The motors installed number about 400, aggregating 5,500 h.p. The lighting points number about 5,000. The output is at the rate of 10,000,000 units per annum, and as already stated the load factor is 80 per cent.

The company have put down in their new works six Mond gas producers which can gasify 17 tons of coal per 24 hours, producing in that time 1,000,000 cub. ft. of gas.

The producer gas is used, among other purposes, in the treatment of pyrites gases for the manufacture of fuming sulphuric acid. It is distributed throughout the various buildings by 54-in., 48-in. and 36-in. mains, and is found a most convenient source of heat, one which can be regulated with the greatest ease. In close proximity to the fuming

* See ENGINEERING, vol. ci, page 187.

sulphuric acid plant is the nitric acid-making plant.

Among the intermediate products manufactured in large quantities in the company's new works—several of which are also made at their older plant—may be mentioned, in the first place, beta naphthol. This is a very necessary intermediate; on it depends the manufacture of acid wool colours, direct cotton colours, paint colours and mordant colours, which, in the aggregate represent a large percentage of all colours manufactured. A building is being completed in the new works for the making of "H" acid (amido-hydroxy-naphthalene-disulphonic acid). This acid is made in the older works in important quantities; when coupled with other dyestuff components there is no other intermediate product that enters into so extensive and varied a range of colours for both wool and cotton. We may also mention, among many other products undertaken by the company, paranitraniline, which, coupled with beta naphthol, produces the red known as Para red; benzidine, the starting point for which intermediate, nitro benzol, has been manufactured by the company for some time on an important scale—it is the basis of aniline oil, a chemical largely used in the dyeing and printing of blacks on cotton; fast chrome blue; chlorazol sky blue, a direct dyeing cotton colour which has always been greatly appreciated by dyers, whether offered under the above name or as benzo sky blue, Chicago blue or diamine sky blue; primulin, &c., &c. Too much emphasis cannot be laid upon the fact that from the very beginning the company have aimed at the production of sufficient intermediate products to enable them to be entirely independent of all outside sources; they are now practically in that position for all the colours they have put upon the market. The company have also successfully met the engineering difficulties which confronted them, such for example, as the obtaining of autoclaves of large capacity, capable of withstanding a pressure of 70 atmospheres; the obtaining also of special alloys to resist corrosion, and so forth.

In the manufacture of numerous products a large quantity of ice is used, and the company have put down an ice-making plant on the Linde ammonia process, which consists of four belt-driven compressors, two having 100-h.p. motors and two 45-h.p. motors. The plant is capable of making 60 tons of ice per day and also of pumping 24,000 gallons of brine at 32 deg. per hour.

Both the older and the new works have a fully-equipped research laboratory. The laboratory at the new works is connected with a model installation on a small scale, in which any product under investigation is made to follow in complete sequence all the various treatments in exactly the same way which obtains in the full-size plants at the works. This makes for saving of time and expenditure.

In the different manufacturing processes throughout the works no waste is allowed; as an example we may state that the bags having contained the nitrate of soda are washed both for increasing the life of the bags and for recovering every particle of nitrate. By-products are recovered wherever this is economically possible.

The work of carrying out the general policy decided by the board and of supervising generally the company's business, is entrusted to a committee consisting of the chairman and three other directors; this committee meets weekly at the works and acts in close co-operation with the works manager. On technical questions, it is advised by a technical committee comprising the chief technical officers of the company in engineering and in works' operations. The main committee also co-operates closely with the technical officers of firms manufacturing plant for, and erecting it in, the company's works. Research is supervised by a Research Council comprising certain university professors and technical officers of the company. The company have paid much attention to the question of research and, as already stated, new processes can be thoroughly tested by means of the model dye-making plant put down in conjunction with the laboratories, before transfer to the works.

In the period, therefore, of about two and a half years which has elapsed since the company began their present development—a period of great difficulty owing to the war—complete plants have been erected and started working for the manufacture of the necessary mineral acids, for supplying the material required for the various colour-making plants, and for producing a variety of dyestuffs. The company have also, as already stated, made considerable progress in the manufacture of intermediate products, and their present installations for the production of these substances are in full operation. Other installations are in progress, and will soon contribute to the output. The company's series and supply of dyestuffs are being regularly increased; they have achieved success in all colours, and particular mention may be made of those derived from anthracene. The company's works, as they now stand, are a most important national asset, and as such they deserve recognition on the part of every citizen. As such, also, they deserve every encouragement on the part of the State as a whole, both in regard to facilities for the sale of their manufactures, facilities on a par with those with which, before the war, enemy products were allowed to flood this country, and in regard to the fostering of research in the dye industry. The company have prepared a scheme for future development, which scheme, when carried out, should not only reduce to a minimum the power of German manufacturers to threaten the British dyestuff industry and through it the British textile industries, but should also enable the company to supply a very great variety of colours in the requisite quantities to all dye consumers in this country.

NOTES.

Photoelectric Cells.

In our issue of August 24 last we referred (on page 206) to the experiments of Mr. T. W. Case, of Auburn, New York, on the photoelectric resistance of a large number of minerals. Case found that certain sulphides, especially bismuthinite (Bi_2S_3), jamesonite ($Pb_2Sb_2S_5$) and some complex silver sulphides, were quite as sensitive to light as selenium, the first two minerals mentioned even more sensitive. His source of light was an arc lamp. Conducting similar experiments, but with a 16-candle carbon lamp, placed mostly at 10 cm. distance from the substance, and with otherwise different arrangements, W. W. Coblentz and W. B. Emerson, of the Bureau of Standards (Journal of the Washington Academy of Sciences, October 19, 1917) did not find any substance which could be compared in sensitiveness with the selenium cell or the potassium-photoelectric cell; bismuthinite and jamesonite proved quite disappointing. Coblentz and Emerson looked for an increase in the conductivity caused by the action of the light, and for an increase in the electrical discharging activity when the substances were charged to a negative potential in an evacuated chamber and exposed to light; they also joined the crystals through a battery to the grid circuit of an audion amplifier and a telephone. But their arrangements were different from Case's; their volts were low and their glow lamp was within 5 in. of the substance. One is rather prepared, therefore, to read that their effects appeared to be more thermal than photoelectric, though they do not draw attention to this fact as a possible explanation for their differing from Case. Meanwhile Case continued his experiments (Transactions of the American Electrochemical Society, 1917, pages 197 to 210) in a different direction by studying the photo-electric action of voltaic couples, one electrode of which is illuminated, whilst the other is kept in the dark. Copper plates or wires have been used in such couples by several experimenters. Case observed that when a carefully-cleaned plate or wire of copper was immersed in solutions of various copper salts, the copper became coated with a film of some lower oxide or halide. When subsequently this coated copper was coupled with an electrode of clean copper (or silver), and one of the electrodes illuminated, a current of 0.11 volt was generated, the illuminated electrode being the anode. The E.M.F. slowly dropped, as in all such cells, under continued illumination. But when the electrolyte was the same salt as had served for coating the copper, and the previously dark electrode of the exhausted cell was illuminated, the current reversed. By interposing a revolving screen in the beam of light (arc lamp or two 600-watt lamps) so as to illuminate the two electrodes alternately, Case obtained a steady alternating current, and the electrodes did not appear to disintegrate. He considers the effect as photochemical. The film on the copper consists of the cuprous oxide or hydrate, which is oxidised under the influence of light, and then dissolves again in the acid of the electrolyte; redeposition of cuprous oxide afterwards takes place. The electrolytes recommended are copper formate and acetate.

Afforestation in Korea.

The annual report on reforms and progress in Chosen (Korea) for the year 1915–16, contains a large amount of information on the development of the peninsula under Japanese administration. Most of this, however, is outside the scope of our columns, but we should like nevertheless to call the attention of our readers to one item which we find of special interest, namely, the work which is steadily being carried out in Korea in the matter of afforestation. With the object of providing the people with a model for afforestation, and also for experimenting in the raising of certain kinds of trees adaptable to the physical conditions of Korea, afforestation on a suburban mountain of Keijo and at other places has been conducted since 1907, and this work was gradually to be transferred to the Local Governments. In the afforestation work carried out by the Central Government, the total area of mountains planted with trees up to the end of the fiscal year 1915–16 was over 2,074 cho (5,080 acres) and trees planted thereon numbered 6,987,000. In addition, 1,835,000 trees were planted on mountains afforested in previous years, to replace those that died. In the work undertaken by Local Governments, the afforestation of State mountains, transferred to the charge of Local Governments, is also conducted as a model for the local people. Afforestation has been conducted by Provincial Governments since 1911, and up to the end of the fiscal year 1915–16, State mountains transferred to Provincial Governments measured 4,704 cho (11,525 acres), of which 825 cho (2,020 acres) were planted with 3,247,000 trees; in addition, 493,000 trees were planted to replace those that died. Further, with a view to arousing in the people an interest in afforestation, the Government General, selecting the anniversary of the demise of the first Emperor of Japan as "Arbor Day," has caused since the annexation of Korea universal planting to be carried out on that day, the first "Arbor Day" being held under the auspices of the Governor-General in Government grounds on the slopes of Nansan, on April 3, 1911. "Arbor Day" arouses much interest among the people in general, especially among the school children. While 4,650,000 trees were planted on the first "Arbor Day," April 3, 1911, over 10,160,000 were planted on the second, 12,430,000 on the third, 13,560,000 on the fourth, and 15,380,000 on the fifth. The total area devoted, to afforestation by private individuals and corporations during the past few years is 53,600 cho (131,320 acres), the aggregate number of trees planted being 184,150,000. From the above it will be seen, therefore, that Japan is conducting this most important work in a thoroughly methodical and effective manner. Her efforts are worthy of imitation, and it is to be hoped that in our present "allotment age," and given the very extensive use we are now making of our available timber resources, the absolute necessity of tree planting will not be lost sight of in this country. Colbert, the eminent French seventeenth century statesman, the right-hand man for a time, until he was unjustly dismissed, of Louis XIV, is reported to have said *la France périra faute de bois.* That was, of course, before the iron and steel age. Nevertheless, this dictum of his contains under various aspects a vast amount of truth for all nations, and should be most carefully borne in mind.

Large New German Steel Works.—The Siegen-Solingen Cast-Steel Union has decided to erect large new steel works at Weyersberg, with foundry and extensive modern installations; it is intended to serve the peace industries, and more especially to supply special steel for the Solingen industry proper.

THE "EXCELSUS" PROPELLER SHAPING MACHINE.

ON June 6 there was a representative gathering from the Air Board, Ministry of Munitions and delegates of the British Aeroplane Manufacturers at Messrs. A. Ransome and Co.'s Works, Newark-on-Trent, to witness a trial of their new patent Propeller Shaping Machine, brought out in conjunction with Mr. J. J. Kerr, of Lincoln.

The trial was in every way satisfactory. Unfortunately no 4-blade propellers were available, but the machine shaped the blades of a 2-bladed propeller, 9 ft. long, the work being excellent, especially the knife edges of the blades. The finish was so good that the propeller only needed touching up with sandpaper after it left the machine.

The machine is essentially a copying lathe, in which the blank is held between one set of centres, or the equivalent of centres, and the model between another set. The two are geared together, so that the blank and the model rotate at the same speed. A roller, 10½ in. in diameter, runs on the model, while a cutter block, also 10½ in. in diam., runs in contact with the blank and cuts it to shape. The cutter block and the roller are both carried on the same swinging angle bracket, and this bracket has a boss embracing a heavy lead screw running down the centre of the bed. In addition to the boss there is a split nut rotated by gearing from the cutter spindle. By means of the nut the swinging bracket is fed along the blank. The cutter block has therefore a steady feed along the blank, while at the same time it is moved towards and from the centre of the blank by the roller running on the model.

It was stated above that the blank is carried between the equivalent of centres. At one end it is supported by a tail stock with the usual dead centre. At the other end is what may be called the driving headstock. It consists of a large ring or bearing, in which there rotates a flanged disc, something like the clutch of a motor car, except that the flange is parallel instead of taper. There is a large hole through the disc, through which the propeller is passed, and an angle plate to which the propeller is bolted by a bolt passing through its boss. The annular flange of the disc carries worm teeth by which it is rotated, the worm shaft also rotating the model at the same speed. When one blade of the propeller has been shaped the blank is unbolted and turned end for end for the other blade to be shaped.

It is impossible to make all the details of the machine clear without the aid of illustrations, which it is not desirable to publish at the present time. Messrs. Ransome and Co. will send further particulars if asked.

PERSONAL.—The "Sentinel" Waggon Works, Limited, Shrewsbury, inform us that they have taken over the works and all the steam waggon business lately belonging to Messrs. Alley & MacLellan, Limited. The new company will deal with all accounts in connection with the sale and manufacture of the "Sentinel" steam waggons, their parts and accessories.—We are informed by Messrs. Henry Ford and Son, Limited, 59, Shaftesbury-avenue, W.1, that a limited number of "Fordson" tractors are now ready for immediate despatch to purchasers.

ROYAL SOCIETY OF ARTS MEDALS.—The Council have awarded the Society's Silver Medal to the authors of the following papers read before the Society during the past session: W. Lawrence Balls, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry"; George Martineau, C.B., "Sugar from several Points of View"; John B. Farmer, D.Sc., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry"; Martin O. Forster, D.Sc., F.R.S., "Organic Chemistry in Relation to Industry"; H. M. Surtees Tuckwell, M.I.Mech.E., "The Tata Iron and Steel Works"; Sir Walter Egerton, K.C.M.G., Governor of British Guiana, 1912–17, "British Guiana and the Problem of its Development."

SHIPBUILDING IN SWEDEN.—A good-sized shipyard will be started at Rönneby; it will, in fact, according to the plans, be the largest in Sweden, with six to eight slips. The new yard will, it is expected, be able to start building in a couple of years' time, and is particularly intended for large cargo steamers. The plan of extending the Karlskrona dockyard so as also to cover the building of merchant vessels, has been met with strong protest from the Union of Swedish Shipowners. In favour of the State scheme it was argued, that a yard of this description would enhance the position of the State in the matter of placing possible future contracts, acting more especially against the formation of trusts. The Shipping Union meets these arguments in an effective manner, and maintains that there is no adequate cause for the State to embark upon such a comprehensive and costly scheme as the erection of a large shipyard for the building of merchant vessels. An extension of the dockyard, as such, is a very different matter.

NATIONAL ENGINEERING WORKS.

Royal Ordnance Factories.—The Ordnance Factories accounts are on a more intelligible plan than those of the Royal Aircraft or National Factories. It seems that materials, wages and some other smaller items are charged against each order or "customer"—the customers being the Navy, Army, India and Munitions Ministry. These are "direct" expenditure. The other expenditure is classed as "indirect," and includes the pay of the managing, clerical, technical and general staffs; maintenance of plant, tools, &c., and depreciation; power, light, transport, rates, and various charges. The "indirect" expenditure corresponds, therefore, to that classed by engineering firms as "establishment" or "overhead" charges. It is not clear how far the principle of making all possible charges direct, rather than indirect, is carried. The factories were worked on monies voted in advance of production as circulating capital, and on a fixed capital of 3,900,000*l.*, increased during the year to 4,600,000*l.* The year dealt with in the accounts is from April 1, 1916, to March 31, 1917. The principal items of the accounts give a general idea of the operations.

Direct Expenses.

	£
Wages and police...	11,578,352
Materials and stores	22,230,001
Indirect expenses	4,559,229

There are various adjustments, which we need not follow in detail, the expenses amounting to a total of 38,000,000*l.* in round figures. The production was to the order of the following Ministries:—

Income.

	£
Navy	4,465,096
Army	433,232
India	13,168
Munitions	27,755,032
Total	£32,666,528
Sale of old stores, &c.	2,013,607
	£34,680,135

The balance, about 3,500,000*l.*, is accounted for by the increase of stores, &c., in hand, accounts owing to the factories, and various balances. The theory of the system is that the income is derived from an advance of money voted by Parliament, the amount of the advance being the estimated cost (in fairly full detail) of maintaining and enlarging the factories; paying salaries, wages, &c.; and buying materials. The actual and the estimated expenditure, under this system, are printed in parallel columns, and the differences adjusted in the annual account. In present conditions the estimates could not be made, but money was advanced as required, and the expenditure classified under the pre-war headings. Parliament, in fact, voted the total amount spent. A table is given, in the Auditor-General's report, appended to the accounts, which includes the following figures:—

Year.	Capital.	Production.
	£	£
1913–4	2,287,000	3,821,000
1914–5	2,718,000	7,699,000
1915–6	3,917,000	19,721,000
1916–7	4,696,000	32,666,000

The heading given in the table, for capital, is given in full as "Book value of fixed capital," and this is correct as the details in the accounts show that the cost of the fixed capital has been reduced by allowance for depreciation—about 10 per cent. "Production," however, is simply given in one word as above, and, therefore, may be read as the "Value of the Products." The accounts, however, give "Production account; for articles manufactured and services performed," and this includes not only services apart from products, but such an item as "Housing schemes for munition workers, 546,793*l.*" Presumably, the ordnance factory "produced" these houses only in the sense of supervising contractors, to whom they passed on the money advanced. So that the comparison of "production" as between 1913–4 and 1916–7 means only that the expenditure on production of guns, ammunition, houses, &c., had increased as shown. No figures are given to show the quantity or value of the guns, ammunition, &c., actually supplied to the Ministry, Army, &c.

Royal Aircraft Factory.—The Royal Aircraft Factory was taken over by the Ministry of Munitions as from March 1, 1917. The accounts just issued by Mr. H. J. Gibson, Comptroller, of the Exchequer and Audit Department, contain no comment, except that the Ministry Audit could not be completed, and that the wages, stores and cash vouching was checked by the War Office. These accounts are for the year ended March 31, 1917. The principal items are:—

Fixed Capital.

	1916. March 31.	1917. March 31.
	£	£
Land, permanent way and mains	19,861	28,586
Buildings...	172,281	204,787
Machinery	78,658	139,330
Stores in Hand.		
General stores	276,750	475,045
Semi-manufactures ...	61,676	77,192

Expenditure.

April 1, 1916, to March 31, 1917.

	£
Salaries and officers' pay	8,055
Services by contractors	8,126
Wages	618,436
Materials...	940,228
Stores	256,121
Electric current	9,542
Town gas	3,289

The principal items of income are given as "Articles manufactured and services performed," 951,865*l.*, and "Stores issued" (almost entirely to the Army), 612,890*l.* The accounts do not correspond to either the commercial or Service forms, and there is no means of comparing the values of income and expenditure. No reference to the kind, quantity or value of output appears, except those just quoted. Stores debits are 532,871*l.*, and credits, 1,087,935*l.*—the inference being that the factory both buys and manufactures stores, but the matter is not clear, except that the word "stores" has not the meaning usual in engineers' accounts. There is no mention of interest on capital or cash used in the business. Depreciation appears as 8,619*l.* on buildings, and 37,178*l.* on machinery.

National Factories.—According to the accounts for the year ended March 31, 1917, published a few days ago, there are 143 National Factories. There are engaged on shells, projectiles, trench warfare and cartridges, 63; explosive and filling, 53; box and salvage, 9; mines and quarries, 7; instructional workshops, 3; and sundry, 8. A "Total balance sheet," for the whole 143 factories, is given in a form somewhat different from the forms of the Ordnance and Royal Aircraft accounts published for the same period. The National Factories are operated with money "advanced" by the Ministry of Munitions. The advances are expended on works and plant, classified as "capital assets," and on current costs classified as "production costs." The total expenditure on works and plant is 38,542,000*l.*, and this is summarised under eleven headings; but it is no use giving the details, as 12,253,000*l.* had not been summarised up to May 31, 1918. No particulars are given as to the quantity or value of the products of the factories. "Articles" were delivered to the Ministry, and the "production cost" of these articles was 235,277,875*l.* 3*s.* 3*d.* The costs in two groups of factories are of some interest in their relative proportions. There are 39 shell factories and 11 projectile factories.

Production Costs.

	Shell.	Projectile.
	£	£
Stores and materials ...	7,192,168	10,616,437
Labour	1,708,385	3,295,352
Repairs and maintenance of buildings, plants, tools, &c.	559,399	1,363,352
Power, light and heat ...	152,691	320,322
Other factory expenses	114,977	243,130
Management and office	213,795	475,170
Special expenditure ...	1,511,600	71,070
Sundries	65,968	—

No allowance is made, in any part of these accounts, for depreciation. This is a serious omission, as the ratio of total cost of fixed capital assets to annual cost of production is about as 1 to 6. No comparison of the relative efficiency of factories is possible, as the groups are each composed of the same kind of factories. No allowance for interest on capital appears. The Auditor-General comments rather severely on the account-keeping both at the factories and at the headquarters of the Ministry.

Whether the National Steel Rolling Mill is included in the National Factories Accounts is not clear. It may be included in the group of Sundry Factories. The following particulars are mentioned in the Auditor-General's report. The original estimate of capital expenditure was 630,000*l.*; at March 31, 1917, this expenditure had reached 755,000*l.*, and a revised estimate showed a required total of 1,200,000*l.* The Auditor-General states that "the actual output has fallen far short" of the expected capacity of the plant, while "the cost of production is considerably in excess of the forecast." The production in 1916-7 was, however, small, and the 1917-8 accounts will show fuller results.

TEXTILE MATERIALS.—An exhibition of materials serving as substitutes for linen, cotton, &c., was held in Berlin in the months of March and April last. Three relatively new materials were noteworthy: nettle, fibre from certain reeds (*Typha*) and peat. Garments, underclothing and household linen, made from these materials, were among the exhibits.

LONDON AND THE CHANNEL TUNNEL.—A paper on "London and the Channel Tunnel" was read by Sir Arthur Fell, M.P., Chairman of the House of Commons Channel Tunnel Committee, at a meeting of the London Society, held in the hall of the Society of Arts. Sir Francis Fox, M.Inst.C.E., presided. Sir Arthur Fell gave a history of the channel tunnel scheme, and stated that it would consist of two parallel tubes. The excavation would be performed by revolving cutters fixed in Greathead shields. The diameter of each tunnel would be 18 ft., and the tunnel would be worked, ventilated and pumped by electricity. Trains would be run from London to Paris in less than six hours. It was considered that the tunnel could be completed by improved methods of construction in about five years. A grandiose scheme was suggested for the construction of a vast station between Waterloo Station and Blackfriars Bridge Road.

BRITISH EMPIRE HONOURS TO ENGINEERS.

A LARGE number of appointments to the Order of the British Empire were announced in a supplement to *The London Gazette*, June 7, and from the list we take the following names of engineers and of others interested or engaged in engineering work. We hope we have not omitted any; but if so, our excuse is that it is not in all cases easy to recognise the recipients of this honour:—

KNIGHTS COMMANDERS (K.B.E.).

Col. Henry Edward Fane Goold-Adams, C.B., C.M.G., late Controller, Munitions Inventions Department; Mr. Horace Darwin, F.R.S., Chairman, Cambridge Scientific Instrument Company, Limited, Member of Munitions Inventions Department Panel; Mr. John Esplen, Senior Partner in the firm of Messrs. Esplen, Sons, & Swainston, Limited, Naval Architects; Lieut.-Colonel Albert George Hadcock, T.D., F.R.S., Managing Director, Sir W. G. Armstrong, Whitworth, and Co., Limited; Mr. Alexander Cruikshank Houston, M.B., C.M., D.Sc., Director of Water Examinations, Metropolitan Water Board; Mr. Harry Duncan McGowan, Managing Director of Nobel's Explosive Company, Limited; Mr. Adam Nimmo, President, Mining Association of Great Britain, Chairman, Board of Trade Committee on the Coal Trade after the War, Member, Central Coal and Coke Supplies Committee; Mr. Percival Lea Dewhurst Perry, C.B.E., Director of Mechanical Warfare, Ministry of Munitions; Mr. Lindsay Byron Peters, Chairman, Engineer and Works Supply Committee, War Office; Mr. James William Restler, Chairman, Metropolitan Munitions Committee; Chief Engineer, Metropolitan Water Board; Mr. Allan MacGregor Smith, Chairman of the Management Committee of the Engineering Employers' Federation; Mr. Harris Spencer, J.P., Chairman of the Birmingham Board of Management, Ministry of Munitions, Chairman of the Midland Employers' Federation; Lieut.-Colonel Albert Stern, C.M.G., Liaison Officer between British and U.S. Tanks Department, late Director-General of Mechanical Warfare, Ministry of Munitions; Mr. John Edward Thornycroft, Director, Messrs. J. I. Thornycroft and Co., Limited; Mr. Seymour Biscoe Tritton, partner, Messrs. Rendel, Palmer & Tritton, Consulting Engineers.

COMMANDERS (C.B.E.).

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HETEROGENEITY OF STEEL.—In 1915, H. Le Chatelier and L. Lemoine proposed a modification of J. E. Stead's copper chloride reagent used for etching steel specimens. In the *Revue de Métallurgie* of March–April, 1918, Le Chatelier and E. L. Dupuy make a further slight change in the reagent, and these workers, as well as G. Charpy and S. Bonnerot, reproduce some photographs of etched steels obtained by different methods with the aid of the reagent. The etching reagent consists of 100 cub. cm. of ethyl alcohol, 10 cub. cm. of water, and 1·5 cub. cm. to 2·5 cub. cm. of hydrochloric acid, and of 1 gramme of copper chloride crystals and 0·5 gramme of picric acid. It is said that these last two constituents may vary considerably, but that the alcohol concentration must be as stated, and that the correct concentration of the hydrochloric acid, the most important factor, can only be found by trial. This statement is hardly clear, because it is evident that with a change in the acid percentage the copper percentage will likewise vary. Le Chatelier recommends to prepare two solutions, the one containing 1 cub. cm., the other 3 cub. cm. of hydrochloric acid; the former would hardly yield any copper deposit, the latter would deposit copper all over the surface; when the solutions are properly mixed, the correct brownish deposit, apparently of oxidic, not metallic copper, and zones of bright metal are obtained. When the specimen is to be photographed, it is, after depositing the copper, placed as anode in a solution (10 per cent.) of sodium bicarbonate and electrolysed for a few seconds with a current of 0·1 ampere per square centimetre of specimen area. On spots where the copper coating is thin, the metal is then redissolved, whilst on spots where there was a thick deposit, the copper is oxidised to a dull-black surface, contrasting well with the bright zones of redissolved copper. All steels so treated show heterogeneity, even if containing less than 0·015 per cent. of phosphorus, it is said, especially after having been quenched and reheated. The thermal treatment itself has no influence on the form or the dimensions of the zones, and the carbon distribution and the presence of other elements hardly have any influence either. The copper is deposited both on the pearlite and on the ferrite; but there are differences. Charpy and Bonnerot use the same reagent, but they place the specimens afterwards in ammonia, which dissolves part of the copper and brings out a pattern, which as a photographic positive, strikingly resembles a negative of the same steel obtained by etching it with nitric acid or iodine, &c. They also differ somewhat from Le Chatelier in the interpretation of the results, stating that the presence in the iron of other metals has the greatest influences of the various factors on the appearance of the zones. The full heterogeneity of steel is not, they consider, revealed by the etching methods so far used. But the dendritic patterns may be 20 times bigger in the central portion of an ingot than in the peripheral region, and as the ingot is rolled down more and more, the parallel striations brought out by the etching become more and more regular.

INDUSTRIAL NOTES.

AMERICA coming into the war has accentuated one problem very acutely. That problem is the heavy demands made upon the world's supply of certain raw materials. To secure its proper allocation from the general pool, the Admiralty is seeking to obtain from its contractors, including ship repairers, their prospective needs of these particular materials. With this in view, towards the end of June, Admiralty contractors will receive forms asking them to state their requirements, and ship repairing firms will receive forms asking them to give their average past consumption during the last six months. It is true that filling in forms is a very unpleasant task for the contractor who "wants to get on with the war." It is obvious, however, that to make the best use of certain materials they must be carefully rationed so as to ensure that the needs of essential war purposes are fully met. This is only possible when these needs are foreseen well ahead, and firms will eventually serve their own interests by filling in and returning the forms without unnecessary delay.

The Ministry of Labour desire to call the attention of employers and workmen in insured trades to the fact that the unemployment books for 1917–18 cease to be current on July 13, 1918, and must be exchanged for new books during the week ending July 20, 1918. Employers should communicate immediately with the nearest employment exchange or other local office of the unemployment fund, if they have not already done so, respecting the special facilities available in this connection. Employers are also reminded that applications for refunds under Section 94 of the National Insurance Acts, 1911, for the insurance year ending on July 13, 1918, must be made in the prescribed manner, and not later than on September 13, 1918. The necessary forms of application and memorandum of instructions (U.I. 220) will be obtainable shortly before July 13 at any Employment Exchange, or other local office of the Unemployment Fund. In order to facilitate the treatment of claims for refund, employers who are proposing to lodge an application under Section 94 (as amended) in respect of not more than 20 workpeople, are invited to forward their claims to the employment exchange or other local office at the same time as they forward the relevant books for annual exchange. The provisions for refund do not apply to workmen insured under the National Insurance (Part II.) (Munition Workers) Act, 1916.

The following are some recent decisions given by the Committee on Production on cases which have been referred to them by the Ministry of Labour.

Shipbuilding Trade (Admiralty Work).—Piecework prices for Admiralty work, in operation before the war, in the shipyards of firms federated to the Shipbuilding Employers' Federation, are to be increased (in addition to the percentage additions to the base prices existing at the outbreak of war) by the following increases on the base prices:—(1) Riveters by 35 per cent. (plus usual 2½ per cent. for holders-up); (2) Caulkers by 20 per cent.: (3) Platers and angle-iron smiths by 10 per cent. The increases are to take effect from the first full pay day following May 23, 1918, except in the case of the Wear and Tyne districts, where the increases are to take effect from the first full pay in March, 1918, and April, 1918, respectively. All additions granted during the war are to be merged in the advances now given with the exception of the general advance of 10 per cent. granted in March, 1915, the war wages advance of 13s. a week, and the bonus of 7½ per cent. on earnings.

Blacksmiths, Shipbuilding Trade.—Piecework prices payable to blacksmiths on merchant work are to be increased by 10 per cent. from the first pay following May 3, 1918.

Woodcutting Machinists, Walsall (National Employers' Federation).—On a claim for the establishment of certain working rules, the committee fixed the normal working week at 54 hours, and the rates to be paid for overtime and for work on holidays. The minimum rate for woodcutting machinists and wood turners at Walsall is to be 1s. 0½d. an hour, and sawyers (excluding pullers-off), 1s. an hour. Men not fully skilled are to receive an advance of 1d. per hour.

Carters, Great Britain.—Except in the case of Liverpool, Birkenhead and district, the war wage advance is to be increased to 25s. a week in respect to drivers (horse and mechanical), stable and garage hands, mates and trailerman. In the case of the workers concerned at Liverpool, Birkenhead and district, a war wage advance of 9s. per week is to be paid. These decisions cover any claims with respect to the bonus of 12½ per cent. on earnings, and any payments made in relation thereto are to merge in the advances now granted.

Sir Guy Calthrop, Coal Controller, on Friday last, delivered an address to the Press on "The New Household Fuel and Lighting Order, 1918," in the course of which he stated that coal stocks were being built up again, as in the summer of 1917, but the public utility undertakings could not have anything like the amount they wanted. After discussion with the gas and electric authorities, the Department had arrived at an understanding that 15,000 cub. ft. of gas should be the equivalent of one ton of coal. It had been suggested by the public utility undertakings that they ought to have taken a higher figure than 15,000 cub. ft., but he had to try and do the fair thing between the gas, electricity, and coal undertakings. . . . Some time ago the Government announced that they must take a further 50,000 men from the mines, and since then a further 50,000 had had to be called on. Each of those men produced between 300 and 350 tons per year. . . . A memorandum stated that not less than a quarter of the coal previously available for domestic use and consumption must be saved. Each ton of fuel will be equivalent to 15,000 cub. ft. of gas, or 800 Board of Trade units of electricity. Fuel may be converted into gas or electricity at the option of the consumer by quarter tons, but not less by a fraction. Owing to the importance of carbonising coal in gas works in the interests of the nation as a whole, it is not desired to restrict the consumption of gas if it can be produced and used in place of raw coal. Unfortunately, it is not possible to manufacture sufficient gas in certain districts to meet the demands, and in those districts it will be necessary to reduce the quantity of gas allowed for each ton of fuel to a less figure than 15,000 cub. ft. The minimum figure may be 12,000 cub. ft., but even this will give satisfactory service to the consumer. Similarly, in more fortunate districts it may be desirable to stimulate the consumption of gas, and in those districts the allowance may be increased up to a maximum of 18,000 cub. ft. It is not possible to avoid this inequality, but the higher equivalents will apply chiefly in the North, and will compensate for the colder climate. These modifying adjustments will only be made when experience of the working of the Order has shown them to be imperative. The production of gas will further be dependent upon the demand.

A London and district branch of the Motor Transport Employers' Federation has now been established, with Mr. W. G. Lobjoit, J.P., as chairman, and with a very strong executive committee representative of the various trade interests in the London area. One of the main objects of the Federation is to bring into existence Conciliation Boards on the lines of the Whitley Report. It is recognised that the condition of industry that will appertain at the conclusion of hostilities will necessitate harmonious co-operation between those who organise and those who carry out the operations, and the transport industry being vital to the prosperity of nearly every other industry, should be among the first to be organised. Any owner of a commercial motor vehicle in the Metropolitan Police area is eligible, and particulars can be obtained from Mr. F. G. Bristow, F.C.I.S., secretary, Motor Transport Employers' Federation, 83, Pall Mall, London, S.W.1.

The Union of Swedish Employers (Svenska Arbetsgifvareföreningen), the largest of Swedish employers' combines, has issued its report for 1917, which shows a continued consolidation on the part of the masters to meet the new contingencies within the realm of labour. The main union now comprises 32 masters' unions, and the number of hands employed by its members amounted, at the end of last year, to 255,144, an increase in the year of some 70,000 hands. It goes without saying that the war has greatly interfered with the industries of Sweden; thus, the paper and the wood pulp industries have had to reduce their production to a marked extent, owing to the adverse conditions for export, and the export of iron and steel manufactures also shows declining figures, which, however, has been counterbalanced by a very material increase in the home consumption, a fact which has enabled the union to avoid any serious degree of unemployment. In this respect, however, prospects look more gloomy at the present time. The union finds decided fault with the labour policy of the State Fuel Commission. It is stated that by offering extremely high wages, the Commission tempted a considerable number of hands to leave their regular occupation, and by engaging men out on strike as well as others, they stimulated, in a way, an inclination to strike on the part of the men.

The Monmouthshire and South Wales Coal Owners' Association, Cardiff, state that the concession of the latest demand of the miners for a further increase of 1s. 6d. per day for adults and 9d. per day for boys under 16, on the basis of the number of workers employed in the collieries of the country in 1917, would add about £22,000,000 to the wage bill, and would increase the cost of coal to consumers by at least 2s. 6d. per ton.

They add that high wages are invariably accompanied by low output—even during the war higher wages have been followed by decreased production. Wages rates since 1915 have been raised to unprecedented levels, but the output per man employed underground in the United Kingdom has fallen from 335 tons in that year to 306 tons in 1917. In South Wales the miners were paid in 1915 a general wage rate of 78·05 per cent. on the standard rates of 1879, and produced 297 tons per man employed underground; in 1916, on a general wage rate of 103·75 per cent., the rate output was 290 tons; in 1917, on a general wage of 133·75 per cent., the output declined to 262 tons.

An enormous quantity of coal is lost to the nation by voluntary absenteeism. The Coal Controller calculates that the new combing-out measures will reduce production throughout the country by about 20,000,000 tons per annum. On the other hand, the elimination of absenteeism would probably make good the whole of that loss. In South Wales, which produces one-fifth of the coal output of the nation, about 3,500,000 tons were lost during the past twelve months through strikes and individual irregularity in attendance. Experience shows that higher wages would tend to aggravate this evil.

The seventy-fifth quarterly balance-sheet, to March 30, 1918, issued by the General Federation of Trade Unions, shows a membership on which contributions are paid of 844,210 and a total gross membership of 1,032,849, divided over 183 societies. The present funds amount to £226,665. At the end of the quarter under review £12,525 was added to the reserve fund. The report states that "during the quarter the Committee continued its efforts to secure the amalgamation of unions that performed similar functions, and it had moved further in respect of apprentices who were affected by the war and of Workmen's Compensation. The Home Office was now appointing a committee to investigate and report. It was to be hoped that the first recommendations of this committee would aim at returning some of those benefits which the Law Courts had reduced or entirely filched away. In spite of the fact that there were so many lawyers in the House of Commons, it seemed quite easy for the lawyers outside to twist the words of an Act until its avowed intentions were defeated.

"Another matter which had concerned the Management Committee had been that of deduction from old-age pension allowances. Some day the Government would awaken to the foolishness of penalising thrift, and it was penalising thrift to make deductions from old-age pensions because the workman had voluntarily contributed to a trade union superannuation fund. The General Federation had always held that the pension should be given as a right, and not as a charity. Every Britisher of every class should be entitled to receive it in full if he chose to apply for it."

The report concludes by saying that the Management Committee had given what support was possible to Ruskin College, to the Workers' Educational Association and to the new Education Bill.

The Whitley Committee on the Relations between Employers and Employed, have presented a further report, which is now published by Dr. Addison, Minister of Reconstruction. It deals with conciliation and arbitration. The Committee pronounce definitely against any system of compulsory arbitration, on the grounds that it is not generally desired by employers and employed, that it has not proved a successful method of avoiding strikes during the war, and that it would be less likely to be successful in time of peace. They also pronounce against any scheme of conciliation which would compulsorily suspend a strike or lockout pending an inquiry.

The Committee advocate the continuance, however, of the present machinery for voluntary conciliation and arbitration, and hope that the setting up of Joint Industrial Councils (on the lines recommended in their earlier reports) will tend to the growth of such machinery. They consider that there should be means for holding independent inquiry into the circumstances of a dispute and for making an authoritative pronouncement thereon without the compulsory power of delaying the strike or lockout. Their main constructive suggestion is that a Standing Arbitration Council should be established on the lines of the present temporary Committee on Production. To this Counci disputants would be able voluntarily to refer such differences as they are themselves unable to settle.

It is suggested, however, that single arbitration should be available for less important cases which could be heard locally. It is further suggested that the Standing Arbitration Council should take means to secure the co-ordination of arbitrators' decisions. The Committee are opposed to the enforcement of awards and agreements by means of monetary penalties. The report can be obtained from H.M. Stationery Office, Imperial House, Kingsway, W.C.2, price 1d.

VARIANCE OF MEASURING INSTRUMENTS AND ITS RELATION TO ACCURACY AND SENSITIVITY.*

By FREDERICK J. SCHLINK, Associate Physicist, Bureau of Standards.

INSTRUMENTAL variance, which forms the major part of the discussion of this paper, is a factor whose effect in causing error in measuring instruments has hitherto been given but little consideration. In order to bring out the essential relations of the variance characteristic, the paper opens with a discussion of accuracy and sensitivity, showing how each of these terms can be given precise definition with definite numerical significance. Such values, when determined, have important use in establishing the figure of merit or value of a given instrument or type of instrument. A distinction is drawn between the commercial accuracy commonly called for in direct reading instruments of the shop and plant, and the higher grade of accuracy required in the laboratory where instrumental indications are normally subject to the application of corrections for error of calibration.

The error arising from whatever source, observed in an indication of the instrument, divided by the true value of the measured quantity may be termed the inaccuracy at a given reading, the negative term being justifiable on the basis of custom and ease in application. The accuracy will be the reciprocal of the quantity just defined. The observed error of an instrument (or the correction) is utilised for adjusting observations before their use in calculation, while the inaccuracy and accuracy find their utilisation in rating the quality or performance of the instrument.

An instrument is understood to be sensitive when it shows a change of reading for any change in the quantity being measured, a definition having little significance until means are available for expressing the sensitiveness numerically. Attention is called to the common inconsistencies in the sensitiveness ratings of familiar instruments, and the suggestion is made that the unit of response, which is referred to the unit of change in the measured quantity in establishing the value of the sensitivity, should be based upon a definite and inherent characteristic of the instrument rather than upon any accidental factor such as the length of a pointer or an arbitrarily graduated scale. Thus in the case of an analytical balance, sensitivity should be referred, not to motion at the tip of the pointer, but to the angular deflection of the beam (or pointer), so that comparison can be made of the true equilibrium properties of balances without reference to the accidental and unimportant factor of pointer length, which, within reasonable limits, is alterable at will. In a balance then, the sensitivity would be determined as the angular deflection of the rest position of the beam per unit addition of load to the load pan, the first expressed in radians and the second in grams.

The necessity for distinguishing between insensitiveness and passiveness or sluggishness in an instrument is shown, and consideration is given to the effect of friction in preventing response to certain small changes in the measured quantity, such that if the usual definition of sensitivity were accepted, we would find a phase of zero sensitivity followed by one of finite sensitivity, consequent upon the overcoming of the static friction which tends to prevent immediate response. Such a discontinuity in the value of sensitivity being irrational, in view of such a determination being dependent upon the absolute rather than the relative values of the quantities entering into the observation, we must modify our definition of sensitivity to this form: sensitivity in an instrument is the rate of change in the indication of such instrument with respect to change in the quantity being measured, it being necessarily assumed for the purposes of this definition that friction and lost motion in the mechanism have been eliminated or are negligible. The amount of the least alteration in the value of the measured quantity, producing instrumental response, divided by the initial value of the measured quantity, may be called the passivity of the instrument at that point. Passiveness is a special case of the phenomenon of variance, next discussed.

Variance is defined as the range, at any given value of the measured quantity, of variation in reading which may be exhibited by the instrument under repeated application of the same value of the quantity being measured, after a steady reading has been attained—the environment remaining unchanged.

The specific variance or variancy may be defined as the ratio of the range, at any given value of the measured quantity, of variation in reading which may be exhibited by the instrument under repeated application of the same value of the quantity being measured, divided by the measured quantity itself, the same assumptions applying as above as to the attainment of a steady state of indication and as to the maintenance of unchanged environment.

Determination of the variance is a most important part of the calibration of an instrument and appreciable error may arise from failure to recognise or express it. The paper illustrates by Fig. 1 (see Figs. 1, 2 and 3 annexed) the derivation of the variance from the hysteresis loop obtained when an instrument is subjected to a complete cycle of operation from a lower to a higher indication, and return—while plotting point by point the instrumental readings (or corrections, or errors) against actual values of the quantity being measured. The importance of a study of this loop in analysing instrument performance is shown, and figures are presented to exemplify the type and magnitude of the effect.

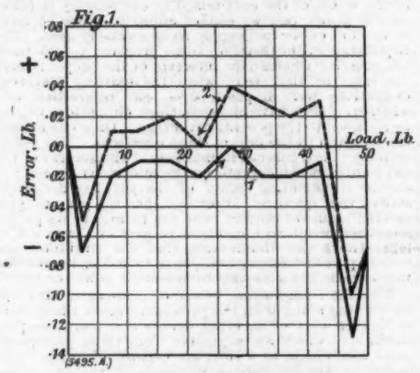


Fig. 1. Hysteresis loop of automatic weighing scale of the campendulum type (comprising no elastic force-measuring elements). Note the manner in which the curve of decreasing readings reflects the aberrations of the curve of increasing readings, with a distinct tendency towards wider separation at the middle of the load range, so that the hysteresis loop would have a distinctly lenticular form, if the median line or mean error curve were rectilinear.

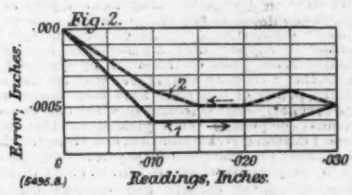


Fig. 2. Hysteresis loop of dial indicator of screw-train type, having high multiplication; an instrument much used for direct reading of small displacements and other linear magnitudes.

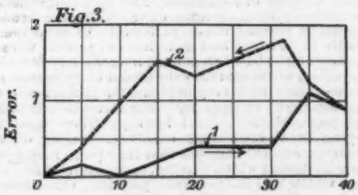


Fig. 3. Hysteresis loop of depth gauge for gasoline tank, a diaphragm type of pressure gauge graduated in inches of gasoline.

The sources of this hysteresis phenomenon are discussed, including the inelastic actions of certain force-equilibrating elements, and, at greater length, the purely mechanistic cause comprised in backlash. In illustrating this latter defect, the importance of maintaining constant or definite space relationships in the instrument linkwork is set forth, and detailed consideration is given to one of the most common causes of imperfect reversibility in instruments, that of the shifting zone of contact in a bearing whose journal fits in a slack or imperfectly constrained manner. The existence of mechanistic causes of irreversibility, quite distinct from the ordinary concept of backlash, is demonstrated, in the rolling of the pin or journal about the interior face of its slack bearing, in a significant and fairly definite manner, capable of kinematic analysis and accounting satisfactorily for phenomena usually ascribed to the operation of frictional resistances simply. It is shown, moreover, that this cause produces an actual alteration and variation of the magnification or displacement ratio of the instrument from the point of reception to the point of registration of the quantity being measured (see Fig. 4).

The frequency curve method of delineation is applied to the expression of variance of an irregular nature, as found in instruments exhibiting bad workmanship or ill repair, and it is seen that the variance characteristic of such an instrument can be completely defined by reference to a family of frequency curves obtained in the following manner: One series of points will be plotted for readings taken at varying rates and amounts of increase of the measured quantity terminating in the value corresponding to the particular point of the scale under investigation, and another set for decreasing values terminating at the same point. Such a curve, in which frequency of occurrence of a particular reading or error is plotted against the true value of the measured quantity at that reading, gives the probability of occurrence of any amount of variation from, say, the mean instrumental reading.

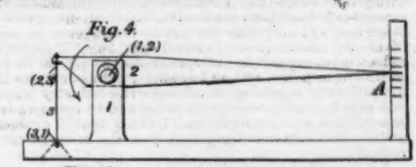
Far from being a relatively unimportant source of inaccuracy in measuring instruments, it can be shown that the hysteresis or variance type of error demands consideration in practically every type of instrument, while in some (such as pointer-and-dial types of displacement indicators) it is a preponderating factor in design, and actually limits the application or utility of the instrument and sets the limit of sensitivity and accuracy practicably to be obtained.

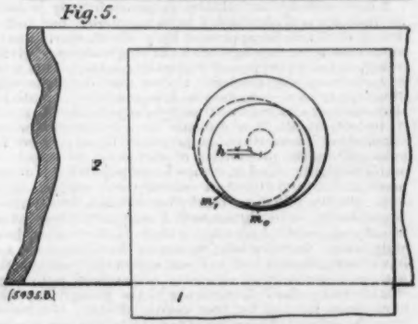
Only brief consideration is given to the phenomenon of instrumental drift, which, having its source usually in elastic after-effects, requires special treatment from the point of view of the elastician.

A few means of reducing instrumental variance are given, including the use of special types of bearings in which slack or clearance can be reduced to a minimum without impairing easy operation; and the use of flexible elastic connectors between elements of the linkwork, instead of gears and racks or pin-and-link connectors. Such tape-like connectors which may wind on cam-shaped members to provide for correction of displacements to a linearly graduated scale, exhibit excellent properties in the matter of reversibility of calibration, and have important advantages over the more usual types of linkwork details.

The action of vibration in reducing instrumental variance is found to accord well with the principles previously set down, and it appears that, within limits, errors of result due to mechanical sources of variance can be considerably reduced by judiciously applied vibration treatment.

In designing and constructing an instrument, due consideration should be given to the effect of variance errors in practically limiting the sensitivity to be sought in adjustment, as well as the interval between the graduations and the smallness of the units of graduation





It is suggested that in view of this condition, the mean interval of graduation of laboratory instruments should not be less than five times the mean variance, while for commercial or plant instruments the ratio of mean scale interval to mean variance may be of the order of two to one. Likewise the sensitivity may easily be disadvantageously high, inducing erroneous estimates of the precision of results and requiring special care in the calibration and use of the instrument.

The factors of maximum or mean inaccuracy (or accuracy), sensitivity, variancy and specific set (the amount by which the variance loop may fail of closure, divided by the range of the deflection cycle) may be referred to the total range of graduation instead of to particular values of the measured quantity under observation, as a convenient means of arriving at single significant members to be composed into a "figure of merit" for an instrument whose characteristics are being determined.

THE GERMAN ALKALI INDUSTRY.—It is a well-known fact that German States have interested themselves considerably in the alkali industry, and a report on the investments of the Grand Duchy of Saxe has just been laid before the legislature. At the beginning of the war the Grand Ducal exchequer owned 198 shares in the Grossherzog von Sachsen works, 680 portions (KUXE) in the Heiligenroda works, 334 portions in the Buttlar works, 50 portions in the Alexandershall works, 35 portions in the Thüringen works, 30 portions in the Kaiserroda works, 11 portions in the Wilhelm Ernst works and 5 portions in the Saxe-Weimar works. In order to acquire these shares and portions the Grand Ducal Government contracted a loan of 5,000,000 marks, in addition to which a loss of 169,000 marks is expected on the Buttlar portions. The exchequer has acquired 99 of the new shares in the Grossherzog von Sachsen Alkali works. The exchequer has found it expedient to dispose of some shares and portions owing to the favourable prices for such stock prevailing during the war, whereby the above debt has been reduced to 4,000,000 marks and new shares acquired, and against these 4,000,000 marks indebtedness, the exchequer now holds shares and portions representing, on April 1, 1918, a value of over 15,000,000 marks.

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*Abstract of paper to be published by the United States Bureau of Standards, Washington. We are informed that persons having problems of instrument design in hand who may be desirous of obtaining copies of the full paper in advance of its publication, may do so by application to the author, at the cost of blue-print reproduction of the manuscript (34 pages and 7 figures).

THE INSTITUTION OF GAS ENGINEERS.

Address by the President, The Right Hon. LORD MOULTON, G.B.E., F.R.S.

I AM fully conscious of the exceptional character of the honour done to me by this Institution in choosing me for its president for the past year. It is true that my acquaintance with the gas industry is of old standing. From outside I have followed somewhat closely its progress for many years, and there are few of the steps which have marked its growth with which I have not been made familiar at the time through one channel or another. But it is not such qualifications as these that win the distinction you have conferred upon me. You have hitherto selected your president from within your own ranks—from those among your members who have been pre-eminent in the practical working of the industry—from those who have been the inspiring spirits of the developments which it has undergone or who have borne the burden and responsibility of managing the works from which the public derive its supply. I can claim no merits of this type. That I am in this position is due to no contributions on my part to the theoretical or practical advance of gas manufacture, but to the fact that perhaps best of all men I can appreciate how great has been your success. No one has had such a unique opportunity of witnessing the response of the industry to new and exceptional demands made upon it by reason of the war. Your industry—typically peaceful in character and aims—has furnished material for purely war purposes without which it would have been impossible to maintain the fight. I have thus learnt as well the flexibility and resourcefulness of the industry as the importance to the nation that all its varied capacities should have free scope. Not only have the benzol, toluol and ammonia produced by it furnished the materials for our high explosives, but in the direction of other needs of very different nature it has given promise of similar usefulness. I have thus been brought to reflect on its capacities of service to the public in war as well as in peace, and as I am here, not as one who has himself done anything to advance the industry but as one who has had occasion to judge and to testify to its capabilities and its successes, I think that I can best utilise this occasion by giving you the fruit of these reflections.

I have styled your industry as pre-eminently peaceful in character and aim, and I have no doubt that such a description will be approved by you. It started little more than a century ago, with the single object of giving locally a public supply of a new illuminant. This must have been sorely needed. Up to that date the only illuminants were oils, fats and waxes, and considering that mineral oils were not used to any practical extent, if, indeed, at all, it is difficult to understand how the supplies of these illuminants could have sufficed for even the barest necessities of the world in respect of artificial light. Had our huge town populations or our present habits of life then existed these supplies must have wholly failed to meet the demand, but smaller populations, earlier hours and, I may add, a less lavish use of soap, made it possible in those times to make both ends meet. It is certain, however, that this could not have been effected had not our ancestors been content with a much smaller intensity of artificial light than would satisfy their descendents of the present day who have been spoiled by the wealth of light obtainable from the unlimited supplies of gas, electricity and mineral oils which are within their reach.

We owe much to the imagination and daring of the men like Lebon, Murdoch and Winsor, who first conceived and sought to put in practice the idea of supplying an inflammable gas as an illuminant. They were innovators rather than inventors. The process they used was not new—it was the same that had been used in the manufacture of coke for at least half a century, and which was known to yield inflammable gas, although this gas was considered of so little value that it was burnt as a waste product. But the conception of conserving this gas and distributing it to the public for illuminating purposes was a bold one and has hardly received the recognition that it deserves. It would not be unnatural that a man should shrink from a proposal to distribute broadcast through the streets and houses of a town gas known to be poisonous and inflammable, carrying with it therefore the risks of death by poisoning, fire and explosion. It is a matter of surprise to me that such a daring project won acceptance so rapidly, and it raises my opinion of the enterprise and initiative of the men of that time. The first application for statutory powers for public gas lighting was made in 1809, and after one failure the application was repeated successfully in 1810, a record which compares favourably with my recollection of the attempts to introduce public lighting some seventy years later. The rapidity with which the movement spread indicates at once the need that existed and the adequacy of the remedy. Within twenty years of this first attempt some 200 public gas companies existed in the kingdom, and by the middle of the century all urban populations must have been supplied with gas.

During all this period, and for many years afterwards, the position of coal-gas in the eyes both of the public and the legislature was purely that of an illuminant. No doubt from the first the possibility of its use as a heating agent was recognised and utilised on a substantial scale in gas stoves, and more especially in cooking apparatus, but it made comparatively little progress in supplanting the domestic coal fire, and even to the present day it is in this direction that, to my mind, its advances have been the slowest and the least representative of its real capabilities. Be this as it may, the fact remains that during the whole of this period its main function was that for which it was originally started and the standard of its duties was rigidly based on this. Great changes were introduced in the practice of gas manufacture, due on the one hand to the introduction of the rival modes of producing inflammable gas known respectively as producer gas and water-gas, and on the other to the appearance in the market in wellnigh unlimited quantities of mineral oils which served both as rivals and helpers of the coal-gas industry. But these changes in practice were necessarily made in strict conformity with the statutory duties, and these duties were based on its behaviour as an illuminant. This remained its purpose and the test of its success. Nothing occurred in the external world of such a nature and of such importance as to alter its general status and aims until about the year 1884, when the introduction of the incandescent mantle on the one hand, and of public electric lighting on the other, so completely changed the industrial position of the gas industry as to justify and even to demand a complete review of the statutory obligations imposed upon it.

Fundamentally the gas industry rests upon the use of a single process usually termed destructive distillation—a name which no doubt is apt to describe it, but one which always jars upon my ear, for to me the so-called destructive distillation is one of the most constructive processes that I know of. It is true that it destroys the crushed remains of past organic life which constitute coal, so that they lose all traces of their past identity, but in their place appear new and definite combinations which correspond in no sense to these past embodiments, even though in some unknown way they may have been influenced or even determined by them. And these new combinations, whether taken individually or regarded as a series, represent no longer the debris of a past world but the building materials of a new one. They show us the early steps through which Nature builds up its most complex work. Man has analysed much of what she has done in the organic world, even going so far as to divine the structure of some of the bodies essential to support life. He has even succeeded in imitating some parts of this work by synthesis. But I think that a chemist would agree with me that in this field the points of departure have been found, and in future probably will be found in some one or more of the many compounds thus yielded by this creative process of destructive distillation, and these the chemist and engineer can when needful separate from the crowd of their companions which are formed along with them.

How are these definite and distinct compounds formed? They are evidently the production of chance encounters of the elements which are present under all sorts of forms and which are brought into intimate contact with one another under all sorts of conditions and in all sorts of sequences. Destructive distillation is the most striking example of the difference between a laboratory process where uniformity of conditions can usually be attained and an industrial process where it is unattainable. The compounds immediately formed in a gas retort, when heated, vary no doubt by reason of the circumstances which regulate the temperatures to which they are first exposed, but their formation is only the first page of their total history. They meet under varying local conditions other compounds of varied character, and the changes that take place may give rise to stable bodies which survive, or to intermediate formations which will in their turn pass into other and more stable combinations before they have run the gauntlet of the total process. Small varieties of local conditions may determine which of these types of action will prevail. It is impossible to predicate or foretell with precision the course of such a conflict of forces. Hence it is that the gas industry owes so little to the laboratory and so much to industrial practice and the results attained therein. In the last four years I have again and again had to learn by sad experience how little one is able to foresee or control the results of destructive distillation, even in the simpler cases where it is applied to hydrocarbon liquids, where it is possible to get some approach to uniformity of conditions. How many times have I been promised priceless benzol and toluol by the use of some special method of carbonisation or of some new system of cracking oils, and how inevitably has failure attended the practical tests. Innovations from which I had been led to expect great things have given results inferior to those given by the old-established practice. The successful methods still remain those which practical experience has discovered and which were adopted with no intention of producing those special results. I have often felt ready to imitate the cynical expression of despair which that great judge, Sir George Jessel, once used when speaking to me of the bad acoustic properties of courts. "If you want to build a room for a special purpose," said he, "be careful to conceal that purpose from the architect. The only court in Lincoln's Inn where you could hear well was built for a library where strict silence was to be enforced."

But if it be true that the *modus operandi* of destructive distillation is little known it is none the less the fact that the accumulation of practical experience on a gigantic scale during more than a century has enabled gas engineers to arrange their methods, and to choose the form and arrangement of their plant, so as to make the final result vary to some extent in the direction which they desire. It is therefore of the first importance that they should be free to adjust their production so as best to meet the real needs of the community. It is not an easy task to arrange for such freedom. Legislative control of a stringent kind must exist. The distribution of gas necessitates the grant to the companies of very special powers such as the breaking-up of streets, the possession of which is admitted to bring with it an absolute monopoly in practice, if not in theory. No company can be put in such a position unless it is willing to accept such legislative control as will define the services which it must be prepared to render to the public in return for those privileges, and will secure the performance of the duties so imposed upon it. Unfortunately, this rigid definition of its duties necessarily stereotypes its work and its aims. However skilfully devised these statutory regulations may be, they suffer under the disadvantage that they were determined by and intended to fit the industrial and economic conditions of the people at the time they were made. Such conditions change from day to day, and in a progressive civilisation like ours may be fundamentally altered in the space of a few years. In the case of private industrial organisations unfettered by statute, self-interest operates so strongly as to lead them at all times to provide as economically as possible that for which there is a demand, *i.e.*, that which best suits the needs of the people at the moment, inasmuch as their success depends on it. Hence we are content in ordinary cases to rely on this, and we should feel instinctively that producer and consumer would alike suffer from any extraneous interference with the natural response of supply to demand. We recognise that interference from without has a tendency to destroy the connection between efficiency and success and to perpetuate what should have passed away as obsolete. But we are too apt to forget that the same principle must apply to cases where for special reasons such interference is necessary as in the case of gas companies. The necessity of doing something does not lessen the price which has to be paid for it, or free us from the penalty if it is wrongly done.

It is therefore essential that from time to time the statutory requirements upon gas companies should be reviewed to ascertain whether they still correspond in the best way to the wants of the world outside. And to this question of public policy a foremost place must be given in view of its magnitude. At least one-tenth of the whole of the coal raised in our country is taken by gas works, and we cannot afford to allow so large an amount of our fuel supply to be unwisely used. The Legislature ought therefore to be prepared to ask itself the question whether the interests of the people remain the same as they were when the existing statutory obligations were imposed upon gas companies, and whether, if they have changed, these obligations cannot be modified to the general advantage. Only one answer can be given to the first of these questions. The public no longer need gaseous illuminants. The success of the gas mantle, which depends on the calorific value and not on the illuminating power of the gas, has decisively settled that question. Provided that the gas will give out the requisite heat to raise the mantle to its proper incandescence it will enable it to give out from six to eight times the illumination that the statutable gas used to give in ordinary use. It is, therefore, immaterial whether the gas possesses illuminating power or not.

Now the illuminating power of coal-gas is obtained by burning along with the permanent gases which form so large a part of it, other denser and more complex substances which are separable from those permanent gases and which, as a rule, are capable of independent industrial use for various purposes. I will not pause here to dwell on these uses. They will suggest themselves to all of you. Some of these substances are capable of being used as fuel in other and more advantageous ways. But it is not only as fuels, which could be better used in other ways, that we regret the substances which are left in coal-gas in order to make it an illuminant. The invaluable hydrocarbons on which our chemical manufactures depend—which give us our dyes and our high explosives—are to be found among them. That a large portion of these valuable substances should be sacrificed to give to coal-gas a property which has ceased to be of value is a loss to the community which should not be allowed to continue. I am, therefore, in entire agreement with what I believe to be the general sentiment of your leaders that existing illumination standards should be abolished and a reasonable calorific value, preferably uniform throughout the kingdom, be put in their place as the standard to which gas should conform. This would enable gas engineers to work with a definite aim and with a great degree of certainty, because the experience of the past points pretty definitely to the means to be taken to secure such a result. It would thus be possible to increase the amount of gas obtainable from the coal used, and the various coal-tar products to whose uses I have referred need no longer be destroyed by being burnt with the gas.

I deem it of great importance, not only to gas companies but also to the country at large, that this introduction of a universal calorific standard for gas should take place without delay. It will put gas and its great rival, electricity, on an even footing in one important respect. Each will be paid in proportion to the amount of energy supplied to the consumer, in the one case in the form of thermal units and in the other case in the form of electrical units. They will have as their confessed object the supply of a like public want, though by wholly different means. Each has its advantages and its disadvantages, and it is by these that its field of use will become delimited. It is in my eyes an industrial mistake to aim at making either displace the other. But in order that the public may reap the full benefit of the two, each must be free to do its work in the best way it can, using all the advantages it possesses both in respect of production and consumption unhampered by needless or harmful restrictions. All this is already true in the case of electricity, but it is not true in the case of gas, and in the future that awaits gas companies it is clear that they will need all the liberty of action that is consistent with their real service to the public to enable them to hold their place in the new industrial conditions in which they will be placed.

This is a moment most suitable for considering what will be the characteristics of that future and how we

should prepare to take our place in it. The experience of the last few years at home and abroad shows that it will differ widely from the past. In the first place, the capacities of electricity for concentrated production and wide distribution have been demonstrated and are being industrially utilised far and near. The present state of things, and the promise of the future, are in this respect in wonderful contrast to the ideas which prevailed in the early 'eighties when electrical distribution was first spoken of. I well remember hearing Thomas Hawksley, the veteran gas and water engineer, say in those days "Electricity is like small beer. It should be brewed at home and consumed on the premises." Never has a prediction been more strikingly falsified, although it was that of a very sagacious man. Schemes of distribution of electricity of the most ambitious and far-reaching character are now being treated as part of practical politics, as may be seen from the report of the Electric Supply Committee which has recently appeared.

It must not be supposed that in referring to them I wish to represent all these schemes as likely to be adopted in the near future, or even that in their entirety they will ever materialise. The calculations on which they rest have no doubt been carefully made, and in a world which, enjoyed absolute immunity from civil disturbance, hostile aggression and world-wide commercial intrigue it might be quite practicable to sit round a table and decide questions of national policy by appeal to the slide rule alone. But, alas! this is not the case in this world of ours. There are many considerations other than those of mere technical efficiency that must come into play before one can decide on the extent to which centralisation should be pushed. The primary necessities of civilisation for our great town populations must be secured by being made to rest on bases so broad that they are safe from sudden disturbance. Centralisation has its drawbacks as well as its advantages. But making all allowance for such considerations I think that we must look forward in the near future to a strengthening and consolidation of electric distribution so far as it can safely be effected, and that in this development it will probably receive support from public funds and will certainly be assisted by largely extended statutory powers. Thus favoured, electricity will be in a position to offer fiercer competition with gas companies in the domain of public lighting, and this furnishes to my mind a strong justification for the demand that there should at once be a revision of your statutory obligations. It is time that you should be free to order your work so as to fit best with what must eventually be the task which will be required from you.

Turning to the other side of the picture we have as a set-off against such an intensified competition the growing appreciation of the value-in-use of the by products of gas manufacture. A good example is that of fuel oil, which is in demand not only for consumption in our Navy but in processes of oil-firing which can be adjusted to wide variations in the character of the fuel used. The value-in-use of this fuel oil has been so marked during the war that research is being energetically pushed forward to ascertain the conditions under which it can be produced in the largest quantities without affecting too seriously the production of other by-products of even greater value. There is the prospect that analogous research will demonstrate the practicability of utilising as valuable fuels portions of that which hitherto has been left unseparated in the tar, and even of using alone, or in combination with them, the least tractable of all your by-products, viz., pitch. A market for the more volatile products (so far as they do not consists of substances too valuable to burn) is fully secured by the universal adoption of internal-combustion engines for road traffic. Foremost among those by-products, which have an intrinsic value apart from their use as fuel, are the members of the aromatic series which are the foundation of our chemical industries. Here the position of the gas companies will be strengthened, I trust, by their finding a home market in the future, instead of having to export them at low prices to assist our rivals to compete with us in the finished products in our own markets. And above all I feel sure that there will be a largely increased home market for ammonia. Our farmers have hitherto lagged far behind in the employment of fertilisers; the nation has trusted to imports to satisfy the bulk of its demand for food. But the war has taught both the farmers and the nation a salutary lesson, and farmers are now ready and eager to use as much fertilisers as they can obtain. The war has shown the existence of a world-shortage of food under the old conditions of cultivation. That which Malthus foresaw and prophesied to unheeding ears has come to pass. Population has outrun food supply, and it has become a necessity to increase the yield of cultivated land. This means that there must be a much larger use of fertilisers in civilised countries, and this change will be specially great in our own country and must show itself in an increased demand for ammonia for home use. And it is precisely in your production of ammonia that there is greatest room for advance. You leave unused much of the combined nitrogen that exists in the coal, and as to which there is evidence to show that it is capable of forming ammonia.

I have been pointing out changes in demand which will be in your favour, and possibilities of reward for successful research in connection therewith. But it must have occurred to many of you that there is another side to the picture—that research in other departments of industry may raise up new competition and that demand may call into operation foreign sources of supply. This is very true, and no more striking instance can be given than the threatened production of synthetic nitrogen at home and the importation of suitable fuel oils from those foreign countries which produce petroleum. Such competition will not lessen the production of ammonia at home, for it is a by-product too valuable to lose, and the same may be said to a certain extent of the other by-products affected. But it will have an important effect on the prices obtained for them, and in extreme cases may even lead to the manufacture of some of them being abandoned. This brings strikingly before us one of the most difficult problems raised by the war. We have learnt by sad experience how costly it is to allow a country to neglect the development of its own internal resources merely because it could get its wants supplied cheaper or more easily by purchase from abroad. To do so with regard to munitions of war would be madness, as the supply would be endangered at the moment when it was most urgently required. But the same may be said of some things which are munitions of peace—things essential to the life of a nation at all times in peace and war alike. We dare not let our own powers of production of such things fall into atrophy trusting to obtain them from elsewhere. To do so to such an extent that national existence depended directly and immediately on such foreign supplies would be like attempting to keep a man alive by continued transfusion of ready-made blood, instead of making him produce his blood by his own natural processes. And it must not be thought that such atrophy is so unlikely to occur that it need not be provided against. If we neglect to make the most of our internal resources the long-continued waste of those resources gets embodied in our plant, in our methods of manufacture, and in our industrial organisation, and when the time of trial comes it may be impossible to eradicate it. The development of its own internal resources has a value to a nation not measured by the immediate economical returns. To reconcile the lessons so taught us with the sound principles of interchange of products which govern industrial life is a problem of overwhelming difficulty. No formula suffices to solve it—the solution must be found in the exercise of a wise judgment in the individual cases which present themselves. But one thing experience has taught me. Those who complain most bitterly of being killed by foreign competition are those who have troubled themselves least to make the best of home conditions, and who have been most negligent in the research which is necessary to bring out the full capabilities of the means at their command. The true remedy of such difficulties is generally to be found in special research. The tendency of research, as a whole, is to kill out the processes which are in the hands of the inefficient. This is as it should be, and we should be prepared to accept the consequences. But where all that careful research can teach is being employed, the subtle adjustment of the value of raw materials and by-products in the industrial market suffices far more frequently than we imagine to secure the prosperity of those who are making the best of the means at their disposal, poor as they may seem in comparison with your highly-favoured rivals.

It is from this point of view that I envisage the future of the gas industry in Great Britain. Probably the most important industrial question in a country like ours is the proper utilisation of its fuel supplies. At first the only method of treating coal was to burn it under boilers, or in furnaces or grates, in the form in which it was taken from the seam. But that is long past. The value of gaseous fuel, first illustrated by the gas industry, was permanently established by the internal-combustion engine on the one hand and by the widespread use of gas furnaces in countless industries on the other, so that now an important proportion of the coal used is divided up into gaseous and solid fuel before being finally burnt, and that proportion is still growing and promises to increase with advancing civilisation. Now gas companies are in the most favourable position to deal with that problem. When put under proper statutory regulations they will be able to make their gas to the best advantage, and they are already in possession of the best market in which to dispose of it. The regularity of the demand and the conditions of production place them in an excellent position to control the nature of their by-products so as to get the best economic return. To do all this so satisfactorily as to face the competition that will arise in the more energetic industrial world that we hope to see develop after the war, will require an equal energy on their part—an equal readiness to improve their present methods where found imperfect. The problems that present themselves are numerous. Such investigations as your Committee on Refractory Materials has been carrying on show how much is yet to be done even in the way of determining the effect of your necessarily high temperatures upon the materials you use in construction. The battles that rage between the advocates of vertical, inclined and horizontal retorts, of high and low-temperature carbonisation, of uniform or graduated temperature, of the use of steam or stripped gas to aid the flow of the gas from the retorts, and many other like subjects of discussion, show how many questions are still unsettled and how many active minds are at work in different directions to perfect your knowledge and increase your powers. All this must be welcomed by you, and where this research has led to clear and definite results you must be ready to adopt them. But the research which will make your industry able to face the difficulties of the future must not be confined to questions relating to production. It is equally important to you to develop the utilisation of gas. There has been, I fear, too great a severance between the two. The means of rendering your products directly and conveniently utilisable to the public have been looked upon as something outside the purview of a gas engineer, not to say something beneath his notice. I think that in future a more liberal view should prevail. There is a solidarity of interests between those who cater for production and those who cater for utilisation. Take the case of gas traction. I am glad to see that this Institution has been giving evidence before the Gas Traction Committee, and I hope that the help you will give to the movement will not be confined to this. In a country destitute of petroleum deposits I think it quite possible that ordinary urban road traffic, which now depends entirely upon petrol, might largely be done by gas, if gas engineers would apply themselves to the problem and get some more practical solution than the fragile and unsightly containers that the public have been ready to accept, and which have at all events shown the practicability of gas traction. All new uses of gas, and all uses that you make easier and more serviceable to the public, go to strengthen your position as producers and as suppliers. Your future will depend on how serviceable you are to the public. If I might use a phrase taken from my memories of Cambridge boating days I should say that "No industry will survive that does not pull its weight in the boat." My view of the gas industry is, it could wish for no better test—that its value to the country is incalculable. This is recognised at the present time, and it will continue so to be recognised, and the industry will maintain its high position in social and industrial usefulness if it realises that the exceptional conditions under which it exists make it more and not less incumbent on it to keep to the front in the activity of its research and its readiness to adopt the best means for performing its important duties. By so doing it will not only render its future secure, but it will merit and win the gratitude of the country.

THE SOLAR SURFACE.—Lecturing on the last two Saturdays at the Royal Institution, upon "Recent Investigation of the Superficial Layers of the Sun," a rind something like 5,000 miles in thickness of a sun of a radius of 430,000 miles, Professor H. F. Newall, director of the Solar Physics Observatory, Cambridge, remarked in the first lecture that theory had to explain, among other things, why the spectrum lines from different parts of the sun differed greatly in intensity, why sun-spot spectra contained lines (due to vanadium), not observed in other spectra, why the spectrum of the limb taken during an eclipse showed bright lines (flash spectrum), not dark lines, and why the sun seemed less bright near the limb than in the centre. The latter fact was ascribed to the "dusty veil" (the corona) which, if close to the sun, would, he said, affect the solar phenomena as our own atmosphere modified the appearance of the sun at sunrise and sunset, much more than if further away from it. The perplexing, partial or total reversals of spectrum lines had correctly been explained by Kirchhoff in 1860, in the light of knowledge of those days concerning absorption and emission and a perfect radiator, but our knowledge of black-body radiation and energy distribution over the spectrum was of recent date, and the important influence of scattering had only been shown by A. Schuster since 1906; these factors affected the distribution over the solar surface of light of different wave-lengths to various degrees. In the second lecture, Professor Newall dwelt particularly on the photographic study of the sun with the aid of the spectro-heliograph in light of particular wave-lengths. When the apparatus was moved across the sun, an image of the whole sun was built up of many chords or narrow strips taken successively. The particular lines chosen were the K-lines of calcium and the hydrogen lines (H α red, H γ blue). Careful examination of the photographs obtained revealed strong differences, when the lights (in which the photographs were taken) differed only little in wave-length, and the photographs suggested an enormous complexity of the structure, accounting for the apparently contradictory statements of earlier observers. Vapours of calcium and hydrogen and other substances were moving upward in some places, downward in others; the instruments and methods allowed us to distinguish layers from different altitudes of the solar atmosphere; as the vapours ascended they spread out in mushroom fashion, while the gas pressure diminished, and the lines from the uppermost layers might appear complementary to those from intermediate layers. But the information from the centre and from the edge of the sun finally led to the same conclusions. The gas pressure could be judged from the breadth of the lines which increased with the pressure. By taking photographs of the same part of the disc at intervals of a few minutes, Hale had obtained stereoscopic effects, and his photographs showed that sun spots were surrounded by enormous vortices, clockwise and anti-clockwise on different sides of the equator, and that the sun as a whole was a magnet like the earth, whilst the dissociated ions (at 5,000 deg. or 6,000 deg. C.) of the vortices would set up powerful local magnetic fields. With the aid of his velocity recorder Deslandres had obtained another type of photographs of the solar disc on each of which thousands of lines and their displacements and reversals could be studied. Working in similar ways, St. John (at Mount Wilson Observatory) concluded that the K_2 line of calcium vapour showed in general a rising movement, the K_3 line a descending movement, in addition to lateral movements; but Professor Newall did not accept that interpretation. Evershed, at Kodaikanal had recently observed that sun-spot lines were always slightly displaced with respect to the same lines in the neighbourhood, and that the actual displacement depended upon the direction of the slit (of his apparatus) with respect to the centre of the disc; there was no shift on a spot at the solar centre. Attention was also drawn to the connection between the dark filaments or tails and the sun spots, into which they seemed to be drawn, and also the prominences, according to Hale, Deslandres, Ellerman and others. Concluding, Professor Newall said that the observations on the sun and stars kept the astronomer on the right lines as to the interpretation of the smaller phenomena studied in the laboratory.

THE MANCHESTER STEAM USERS' ASSOCIATION.

THE annual meeting of this Association was held at the office, 9, Mount Street, Manchester, on Tuesday, June 4, the president, Mr. Harold Lee, J.P., in the chair.

The report stated that, compared with 1916, the total number of boilers under inspection showed an increase of 348, and the income from all sources amounted to 24,533*l.* 7*s.* 3*d.*, the highest yet recorded. The net surplus for the year was 913*l.* 6*s.* 1*d.*

The gross total of boiler examinations in 1917 was 22,275. Of these, 11,206 were "internal," "flue," and "entire," the highest number hitherto reached in one year. The main object which the pioneers of the Association had in view was the prevention of boiler explosions and the saving of life and property by the systematic and thorough inspection of the boilers, and the committee continued to keep this principle first and foremost in the essentials of the Association's activities. No explosion had occurred from any boiler under inspection and guarantee during the year, and no life had ever been lost from any cause which the Association could or ought to have prevented.

In the department dealing with the inspection of boilers and working plant, the service rendered during 1917 had been in many instances of special advantage to the members concerned. First inspections were made of nearly 700 boilers and pressure vessels, in addition to steam-pipe ranges. About 7 per cent. of the boilers required structural strengthening to render them fit for work, or were unsuited for the purpose intended.

The proportion of second-hand boilers examined before purchase had again been large, and some of these had been found quite unsuitable for the requirements for which they were submitted, although offered at very high prices. In such cases intending purchasers had seen the wisdom of consulting experts before purchasing.

The wave of boiler mishaps mentioned in the last annual report seemed to have passed away. It was attributed to the employment of inexperienced firemen owing to the exigencies of the war, but further experience and the fact that the men have come in contact with the Association's inspectors when examining the boilers, and had had the opportunity of receiving advice, had led to their giving more intelligent and vigilant attention to their duties.

The report stated that the "record of boiler explosions for 1917 outside the Association's ranks, showed an extraordinary falling off, difficult to explain. The employment of inexperienced or careless men in charge of boilers would naturally have led to the expectation that the number of explosions would have increased, but the contrary appeared to have been the case. Since the date of the last compilation, the Association had received only five reports of inquiries by the Board of Trade under the Boiler Explosions Acts. Those referred to three explosions "proper," by which two persons were killed and six injured; and two "miscellaneous" explosions, killing two persons and injuring one other. Of the five Board of Trade reports issued on these explosions, two dealt with formal investigations, towards the cost of which the parties found in default were ordered to pay to the Board of Trade sums varying from 10*l.* to 200*l.*, and amounting in all to 380*l.* As the last report to hand referred to an explosion which occurred in October, there might be others to add when the complete Board of Trade returns for the year were published."

The chairman, in moving the adoption of the report, referred to its generally satisfactory character. The difficulties during the progress of the war had been very great, and, if possible, had increased during the year, but the Association had successfully maintained the efficiency of its inspections with gratifying results, and thanks were due to the efficient staff for their energy and the faithful service they had rendered. The original object of the formation of the Association 64 years ago, viz., the safe working of steam boilers by efficient inspection, was kept constantly in view, and not only was the question of safety dealt with as the main guiding principle, but also efficiency and economy in working. The Association's work was an educational one for the boiler attendants and of considerable commercial value to the steam user. The cost of the inspection of a boiler was but a small item compared with the possible financial gain in savings effected.

Inattention to boilers by negligent or inexperienced stokers had been again the cause of what might be termed minor accidents during the war, but, as stated in the report, these had been less during the past year.

The subject of research in various direction was a branch of the Association's work which, the chairman said, he would like to see greatly extended. Especially did he think that as soon as opportunity offered, they ought to make practical investigations in problems to secure further efficiency and economy in the use of existing plant on a more extended scale than hitherto. Some very useful work, however, had been done, and many problems in boiler construction, to secure still further safety and efficiency, awaited the opportunity of the chief engineer and his staff when the pressure of war work was relaxed. A question the chief engineer had been investigating was in connection with the distribution of stresses in bolts and nuts, and the subject being a new one, it might be summarised as follows:—Engineers had, in the past, been content to assume that the stresses in bolts and nuts are uniformly distributed amongst the interlocking threads. The assumption was fairly correct when bolts and nuts were made of plastic materials like iron, mild steel, copper, or brass. But this assumption was not strictly true, and as long as the assumption of uniform distribution was adhered to as being correct, further progress was barred, more particularly as regards the substitution of high-tenacity steel for the commonly used mild steel. If high-tenacity steel could be used, then the dimensions of bolts and nuts could be reduced 30 per cent. or more, but high-tenacity steel could only be used if bolts and nuts were designed on theoretically correct lines. The work on which the chief engineer had been engaged was of the same nature as that done by the French mathematician Navier. Both principles were practically the same, but the one was applied to guns, whereas the chief engineer's was applied to screws. It was well known that guns had been improved from an effective range of 500 yards for our own 65-pounders to the wonderful results obtained from the latest gun which has a range of 70 to 80 miles, or 110,000 to 140,000 yards. This advance was due to the application of correct principles of gun construction, whereby the use of high-tenacity steel had been made possible. The same principle applied to bolts and nuts would effect a similar, a more peaceful, and, therefore, a more useful, revolution with regard to them.

Dr. Edward Hopkinson seconded the motion for the adoption of the report, and said the war had thrown considerably more work upon the staff, but had added to the Association's influence. The great number of munition factories set up with great rapidity all over the country were all dependent upon power for their working, and this had necessitated the installation of boilers in most instances very hurriedly. This had meant second-hand boilers, and it was imperative that special care should be given to the inspection of the boilers to see that they were of suitable strength for the purpose, and also to the instruction of the attendants. In this respect, the Association had done useful work during the year. If this country was ever to recover economically, it could only be by an enormous increase of its productive power, and that must be accompanied by, and be very largely dependent upon, an increase of motive power. It was well known that the power (horse-power) available in the United States per head of the population was several times as great as that available in the United Kingdom, so that undoubtedly after the war, when the process of reconstruction set in, there would be a very great increase in the installation of power. In design and research in connection with this power of production, and in the expansion of it, the Association would in the future have a great part to play.

The motion for the adoption of the report was then put to the meeting, and carried.

Captain Provan, of the Mechanical Transport Department (War Department), proposed a resolution thanking the committee for their services for the past year, and proposing their re-appointment for the coming year. He referred to the increased use of steam as against petrol-propelled vehicles, and said that as regarded economy, there was no comparison whatever, steam having the advantage by five to one. This would, he thought, have an important bearing after the war. The resolution was put to the meeting and carried.

CHINA: MACHINERY AND ENGINEERING SITUATION.—The demand for machinery and engineering supplies in China is considerably in excess of the supply that can be obtained from the various manufacturing countries, says *The Shanghai Chamber of Commerce Journal*. There are many orders ready to be placed, but withheld owing to the fact that the buyers are discouraged by the present high prices and uncertain deliveries. Not only are large undertakings, such as railways, deferring purchases in the hope of better times, but many industrial proposals are indefinitely shelved for the same reason. No doubt in quite a number of cases buyers are so discouraged that inquiries never reach foreign firms, but there is a sufficient number of proposals coming before merchants to prove the buoyancy of the demand. Interest is still maintained in cotton spinning and weaving mills, flour mills electric lighting plants, metallurgical plants, and a host of smaller applications of an engineering nature. In many cases machinery costs from 100 per cent. to 150 per cent. more than before the war. Some materials have risen to an even greater extent, notably steel for ship-building. The rise in prices is, of course, a natural and inevitable outcome of the war, and can safely be expected to continue until peace is declared. As far as China is concerned, this rise in price is offset to a considerable extent by the present high exchange. On the other hand, exchange has not remained steady during the year, and whatever the general level may be, such violent fluctuations will always act as a bar to trade. Of the other elements making up the landed cost of the goods, freight is the most important. During 1917 freights from Great Britain rose steadily, but not very rapidly. As regards the United States, opportunities of shipment *via* Panama are not frequent, and practically everything is coming by rail to the Pacific Coast. Through freight from the Eastern States to China rose sharply, but not steadily, during 1917, and all through the year it was almost impossible to work out freights in advance, as the market seemed to vary from day to day, and the greatest uncertainty existed, not only as regards the ocean freight across the Pacific, but also as regards railway rates in the United States. A further difficulty in connection with these shipments was the congestion at all Pacific ports. There are not a few cases where goods have remained on the coast awaiting tonnage for five or six months. The difficulty of obtaining supplies from the United Kingdom remained practically unaltered during 1917. At the beginning of 1917 the United States were not at war, but since they have joined the Allies, licence regulations for manufacturing and for export have been rigorously enforced. The result was that at the close of the year it was not much easier to obtain goods from America than from the United Kingdom. It is also a noteworthy fact that such goods as could be obtained from the British Isles were considerably lower in price than similar articles purchased in the United States.

CATALOGUES.

Steam Jointing.—A catalogue of black sheet jointing, from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. thick, capable of withstanding high pressure and superheat without cracking, burning or blowing out, comes from the Powerite Steam Jointing Company, Limited, Oakamoor, North Staffordshire, and 8, Brabant-court, Fenchurch-street, London. It is sold by weight, all thicknesses at the same price per pound. A cheaper material for cold-water joints, insulation, &c., is also produced.

Steam Fittings.—A series of fittings most in demand at present are illustrated and briefly described in a folder catalogue issued by Messrs. Holden and Brooke, Limited, West Gorton, Manchester. These include injectors, ejectors, water heaters, boiler-feed water heaters, steam and vacuum traps, oil separators, centrifugal pumps, &c. Complete catalogues of any of these are also supplied on request. All these are substantially made in a full range of sizes and ready to put into service.

Hydraulic Machinery.—Hydraulic pressure machines have come into larger use during the war, production being very much diverted from standard industrial types to special metal pressing, tube drawing and wood pressing types for munition work. The Hydraulic Engineering Company, Limited, London and Chester, send a catalogue which has been specially prepared for circulation abroad. Cotton-baling presses are shown in several forms; a veneering press with a series of steam-heated plates; dock, roof and jetty cranes; capstans; an automatic injector for fire extinguishing; and an intensifier for giving the main part of the stroke at low pressure and the finishing part at high pressure. The pumps are all of the single-acting ram type, with three or six rams producing working pressure per square inch of 250 lb. to 3 tons. Several pages of useful hydraulic memoranda are added.

Electric Current Transformers.—Static transformers, for normal pressures below and above 10,000 volts, are very fully described in a catalogue received from the Brush Electrical Engineering Company, Limited, Falcon Works, Loughborough. The specification gives clear and precise particulars of the core, windings, clamping, terminals and tanks, both as to materials and construction. The design is for a temperature rise, after continuous operation at full load, of 45 deg. or 50 deg. C. Designs for lower rises are available if required. Each transformer is tested at full load for temperature rise and also to find the values of copper loss and impedance volts, iron loss and magnetising current, and voltage ratio. Efficiencies are guaranteed to within 0·05 per cent. of the values specified. A tabular statement is given of overall sizes of 21 three-phase transformers.

Marine Turbine Gear.—The Power Plant Company, Limited, West Drayton, Middlesex, send a special catalogue showing drawings and specification of a new gearing unit for fitting on board ship. The large wheel, for coupling to the propeller shaft, is driven by two compound wheels, which in turn are driven by steam turbines. A turbine speed of 3,000 r.p.m. is thus reduced to a propeller speed of 70 r.p.m. or from 44 to 1. The smallest pinion has 25 teeth. The design allows great compactness and rigidity. Each gear and bearing has its own supply of oil, and the bearing covers are all removable without undoing the main casing. Twenty sets are under construction, and the firm supply complete units, cut gears without housing, or licences to manufacture the whole or part of the mechanism to their patented design.

Works Canteens.—For many years cooking appliances have been made on a large scale by engineering firms, but the chief buyers were Boards of Guardians and hospital governors—and these institutions have long been foremost in good cooking. It now seems that the workman is to be as well fed in the useful as in the other periods of his life. A 20-page catalogue from the Richmond Gas Stove and Meter Company, Limited, Warrington, shows a complete range of ovens, steamers, boilers, hot plates, &c., and out of a list of 40 buyers of these kitchen equipments all but one or two are engineering firms. There is no attempt in the catalogue to offer cheap makeshifts; everything is substantially made, of the most suitable materials and best finish. This implies that, as a matter of course, the cooking department is being made a permanent addition to the many works departments. That the employer is willing to pay the cost is taken for granted all round.

Electric Motors.—Those who are putting in electric motors are not always learned in the peculiarities of different types of that machine, and the electrical engineer has not always been quite loyal to the use of plain English words. Catalogues of electrical machinery are chiefly addressed to men of fair general mechanical knowledge, who, however, are often baffled and irritated by the foreign terminology of electricians. There is a general tendency nowadays to break away from this style and to recognise that a man who has anything to say or to sell may strive to make himself comprehensible without loss of dignity. A catalogue of the British Thomson-Houston Company, Limited, Rugby, dealing with two and three-phase induction motors sets a good example with a page or two of preface explaining the induction motor, the special qualities of the squirrel cage and slip-ring varieties, the different methods of ventilation and the plain meaning of a few necessary terms. This is followed by complete technical information and measurements. These motors, for alternating current, are being more widely used, several hundred different adaptations of powers ranging from 0·5 h.p. to 450 h.p. being fully listed in the catalogue.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c. of the Communicators are given in Italics.

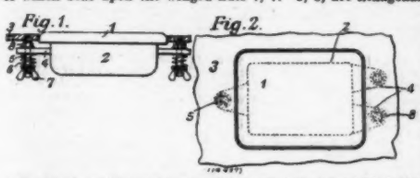
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

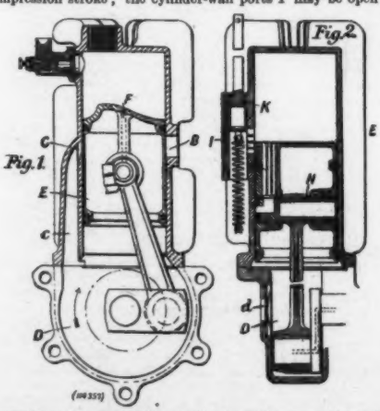
114,437. F. P. Fletcher, Finchley, London. Electric Cooking Stoves. (2 *Figs.*) May 7, 1917.—The invention relates to that kind of electric stove wherein hot plates movable vertically are arranged in corresponding holes in the hob or main plate. 1 is the hot-plate containing the heating element within its heating chamber 2, and 3 is the hob. 4, 4, are lugs on the hot-plate 1, by means of which the hot-plate is so sustained that it normally projects above the surface of the hob, but may be depressed by a utensil placed upon it. 5, 5, are pins screwed into the lower surface of the hob and which pass through orifices in the lugs 4. These pins are embraced by helical springs 6, 6, the upper ends of which bear upon the lugs and the lower ends, of which bear upon the winged nuts 7, 7. 8, 8, are hexagonal



nuts placed on the upper side of the lugs between which latter and the nuts spring washers may be placed. The action is as follows. When a utensil sufficiently large to more than cover the hot-plate is placed thereover, the hot-plate is depressed and the weight of the utensil is borne mainly by the hob whilst the hot-plate is pressed upwards, against the bottom of the said utensil, by the springs 6. Adjustment of the pressure of these springs is effected by the screwing up or down of the nuts. If the utensil be smaller than the hot-plate its weight may be either entirely borne by the hot-plate or partly borne by the hot-plate and partly by the hob, according to whether the utensil is placed centrally with respect to the hot-plate or so as to overlap a part of the hob. (*Accepted April* 17, 1918.)

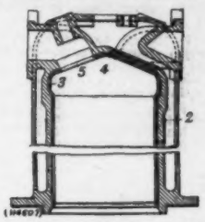
GAS ENGINES, PRODUCERS, HOLDERS, &c.

114,357. C. G. Pullin, Barnes, London. Internal-Combustion Engines. (3 *Figs.*) May 3, 1917.—This invention relates to an improved method of operating an internal-combustion engine. The means which constitutes the important feature of this invention is the withdrawal of some of the air from the cylinder on the compression stroke, by means of a passage F through the piston E and the gudgeon-pin H which communicates with one of several separate ports I for the purpose in the cylinder wall; the opening of these ports may be controlled externally by a suitable valve according to the amount of air, gas and compression needed for the particular power or speed required at the moment. Owing to the varying obliquity of the connecting rod, the angular position of the gudgeon-pin H in relation to the air passage F through the piston E continually changes; the said passage may be closed altogether on the firing stroke by turning the passage openings out of register, but may be open on the compression stroke; the cylinder-wall ports I may be open for



a greater or less part of the stroke, depending upon the position of the fuel control valve of the engine, and consequently of the air-release valve externally controlling the openings in the cylinder wall, the throttle valve and the release valve being interconnected in order to achieve this result. It should be understood that the cylinder wall release ports are only operative when the gudgeon-pin passage is opposite to them. Preferably the air-release valve may be in the form of a reciprocating piston valve K, and since the air and fuel required are directly proportional, the connection of the release valve to the fuel valve may be by any suitable means giving a directly proportionate movement of one to the other. In the case of the two-stroke engine, the preferred means of delivering air to the cylinder is to fill the crank-case D through an automatic valve *d*, to transfer it therefrom through a passage *c* to a port C in the cylinder wall uncovered by the piston E approximately at the same time as an exhaust port B in order that a complete scavenging action may take place at all speeds. (*Accepted April* 10, 1918.)

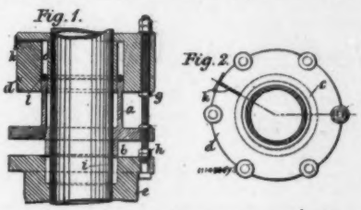
114,607. S. S. Guy, Finchfield, Wolverhampton. Internal-Combustion Engines. (1 *Fig.*) January 18, 1918.—This invention has reference to internal-combustion engines of the type in which the cylinders are made of light metal and cast around a liner of a more durable and wear resisting metal. According to this invention, the liner 3 is formed in one or more pieces by a pressing, stamping or forging process or by combinations of two or more of such operations and subsequently



machined. The drawing illustrates the application of the invention to the water-jacketed cylinder 2 of an internal-combustion engine. The chief merit of the invention lies in the fact that the steel liner 3 is fashioned or formed by a pressing, stamping or forging process so as to extend to and completely line the whole of the interior of the combustion chamber 4, irrespective of the shape of the latter and, moreover, in such a manner as to provide steel seatings 5 for the valves. (*Accepted April* 17, 1918.)

HYDRAULIC MACHINERY.

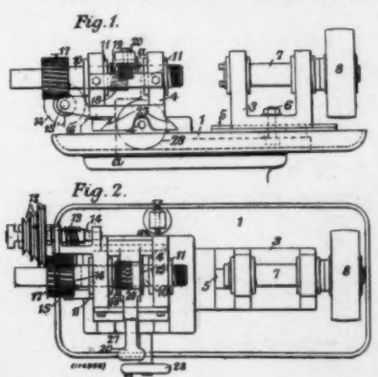
114,504. The Hydraulic Engineering Company, Limited, Chester, and R. Calvert, Westminster, London. Stuffing-Box Glands. (2 *Figs.*) April 30, 1917.—The invention relates to a method of automatically regulating the pressure of the packing in a stuffing-box of a hydraulic accumulator or like cylinder, and consists in subjecting the gland to external fluid pressure higher than the internal pressure to which it or its packing is subjected. *a* is a cylindrical extension of the gland *b*; it is of slightly increased cross-section at its end which works as an annular piston in a cylindrical cavity *c* in a crosshead *d*. The latter is connected with the stuffing-box *e* by screw bolts (in this



case six) extending with some play through the crosshead and the flanges of the gland and the stuffing-box. Nuts *g*, working on these bolts, serve for applying initial pressure to the gland while other nuts *h* serve for lifting the gland when the packing *i* requires attention. The cavity *c* communicates with the hydraulic cylinder through passage *k* so that pressure is exerted on the end of cylindrical extension *a*, a tight joint being made by an annular cup leather *l*. Since the area subject to pressure in cavity *c* exceeds that in the stuffing-box, the external pressure on the packing will exceed the pressure on it exerted directly from within the hydraulic cylinder. (*Accepted April* 17, 1918.)

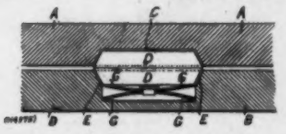
MACHINE AND OTHER TOOLS, SHAFTING, &c.

114,352. W. H. Pick, Leicester. Thread-Milling Machines. (4 *Figs.*) April 25, 1917.—This invention relates to screw-cutting or thread-milling machines. The thread-milling machine comprises a bed 1 mounted upon a stand, and the bed-supporting headstocks 3 and 4. The headstock 3 is slidable along a guide 5 on the bed and is secured in position after adjustment by a bolt 6. The headstock 3 supports a cutter spindle 7 driven by a pulley 8. The headstock 4 carries a work spindle 10 which is both rotatable and movable axially in the bearings 11. Conveniently the rotary movement is imparted by means of two sets of worm gears from pulleys 12. The worm 13 (Fig. 2) drives



a worm wheel 14 (Fig. 1) on the spindle 15 of which is a second worm 16 which drives a worm wheel 17 (Figs. 1 and 2) fast on the work spindle 10. The spindle 10 is freely slidable through the bearings 11, and for imparting the axial movement it carries a copy screw thread 18 adapted to be engaged by a sectional nut 19 (Figs. 1 and 2) attached to a hinged arm 20. The copy screw thread 18 is of the same pitch as the screw thread to be cut on the work. The copy thread is preferably formed upon a sleeve or hob which may be removed from the spindle 10 so as to be interchangeable with others having threads of different pitches. Likewise the sectional nut 19 is removable from the arm 20 for the same purpose. The headstock 10 is mounted to move along a cross traverse slideway 27 (Figs. 1 and 2), being actuated therein by the well-known screw-and-nut means operable by a hand wheel 28. In using the machine the milling cutter is fixed in the end of the spindle 7, and the piece to be screw-threaded is mounted on the work spindle 10. The nut 19 is engaged with the copy thread 18, the spindle 10 being in the normal position. The cutter spindle 7 being started, the work spindle is moved forward to feed the work into contact with cutter until the proper depth of cut is obtained, whereupon the rotation of the work spindle is started during which the work will be traversed by the copy thread, thus giving the correct pitch to the screw thread being cut, a complete thread being formed in one revolution of the work. After cutting the threads, the work spindle is withdrawn and its rotation stopped, whereupon the work may be removed, and by lifting the nut the spindle may be returned to the starting position, and is ready to receive another piece of work. (*Accepted April* 10, 1918.)

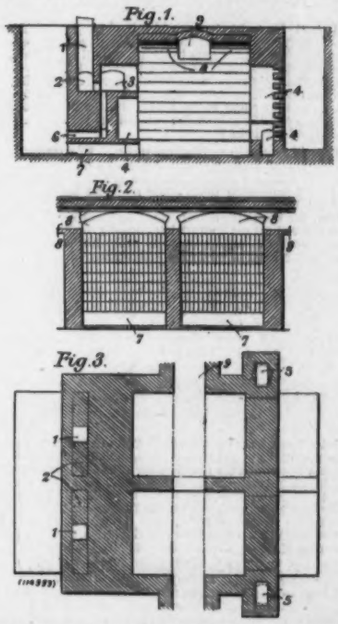
114,375. J. McNeil, Kinning Park, Glasgow. Heavy Machine Tools. (2 *Figs.*) July 5, 1917.—The invention has for its object to provide in connection with machine tools, such as slotting and milling machines, hydraulic forging presses and the like dealing with heavy work, means for relieving the work table of all or any desired portion of the weight of the work. In carrying out the invention, there is provided in the under side of the table A, which is rotatable in usual manner on the platen B,



a central recess C to receive a circular bolster D, which enters a counterpart recess E in the platen B. Beneath the bolster D and between it and the platen B is arranged a series of Belleville washers G, the spring effort of which is sufficient either to entirely overcome the load due to the weight of the work upon the table A, or to so far do so that the table may readily be rotated upon the platen. The springs are, of course, not of sufficient intensity to resist the pressure due to the operation of the press. (*Accepted April* 10, 1918.)

MINING, METALLURGY AND METAL WORKING.

114,333. W. J. Mellersh-Jackson, London (*Ch. M. Stein and Cie., Paris, France*). **Hot-Blast Stoves.** (3 Figs.) March 24, 1917.—It has been amply demonstrated that the consumption of the fuel in a blast furnace is, all things being equal in other respects, reduced in proportion as the air led to the tuyeres is hotter. The temperature to which the air is heated is, moreover, limited by the temperature to which the checker-work of the stoves of the Cowper or Whitwell type employed at the present day can be raised. The blast-furnace gas or any other gas coming either from gas producers or from coke ovens



arrives by the conduit 1 and by the flue 2. It comes to the combustion chamber 3, where it is burnt by the air which is conducted into this chamber 3 through the flues 6. The products of the combustion circulate in apparatus resembling a continuous regenerator and through the flues 4, and are discharged to a chimney 5. The air or gas intended for heating the Cowper or other stoves enters the apparatus through the flue 7, and after being heated in contact with the sides of the flues in which the gaseous products of combustion just referred to are circulating, it reaches the Cowper or other hot-air stoves by traversing the chambers 8, the flues 9 and suitable valves. (*Accepted April* 10, 1918.)

RAILWAYS AND TRAMWAYS.

114,404. A. Spencer, London. Lubricating Railway Axle Journals. (4 *Figs.*) November 29, 1917.—This invention has for its object improvements in apparatus for lubricating the journals of railway axles and the like. This invention consists principally in providing, in addition to the oil reservoir or receptacle 5a in the lower part of the axle-box, a second oil reservoir or receptacle in the upper part of the axle-box immediately above the bearing brass on top of the journal, the second receptacle being in communication with the space in the axle-box and having suitable holes through which the oil delivered into the receptacle, through a pump delivery pipe which leads into the receptacle, flows or drops by gravity on to the journal. According to one embodiment of this invention, the pump barrel 6 is situated

outside of the axle-box and connected thereto at its lower end. The suction passage 7 is provided in a part of, or connected to, the lower end of the pump barrel 6 at right angles or at approximately right angles to the barrel, which may extend upwardly parallel with the side of the axle box. At the outer end of the suction passage 7 the suction valve 8 of the pump is provided; leading out of the side of the pump barrel is the oil delivery port 9, which communicates at its outer end with a valve chamber 10 in which is the discharge valve 11. An oil delivery pipe or

Fig. 1.

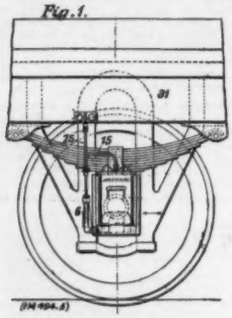
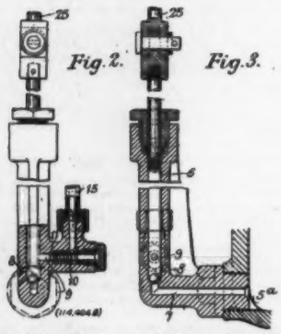
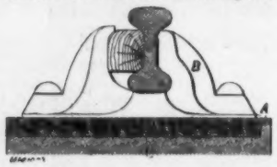


Fig. 2. Fig. 3.



passage 15 leads from the chamber 10 into the top of the axle-box the end of which pipe is in communication with a port through the top of the axle-box, which port leads into an oil receptacle in the upper part of the axle-box, and oil outlet holes are provided in the bottom of the said receptacle so that the oil can pass therefrom and through other holes in the bearing brasses to the journal of the axle. The upper end of the pump plunger 20 is operatively connected by a rod 25 to the underframe of the vehicle 31. (*Accepted April* 10, 1914.)

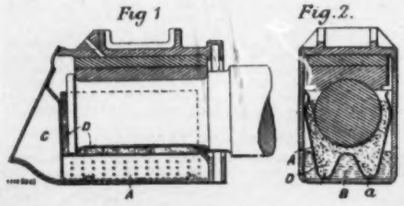
114,102. J. Robbins, Westminster. Permanent Way. (1 *Fig.*) August 7, 1917.—This invention relates to railways in which the ordinary wooden sleepers are dispensed with and the chairs are supported upon some material liable to become disintegrated by the vibration to which it is subjected under traffic such, for instance, as concrete, and has for its object to provide improved means comprising packing material which will efficiently absorb or counteract such vibration and prevent its being transmitted to the concrete. According to this invention,



there is introduced between the chairs and the concrete a packing of fibrous material in rope-like, corded, coiled, twisted, or intertwined form, together with plastic cement of such character that, whilst it is water-resistant, it is not liable to become hard, or friable. A sleeper A is shown recessed at *a*. In this recess *a* is introduced the packing, consisting of a combination of fibrous material, in an aforesaid form, and a water-resistant plastic cement not liable to become hard, or friable. Upon this packing the chair B is placed. (*Accepted March* 27, 1918.)

114,522. T. F. Craddock, London (*Burn and Co., Limited, Howrah, Bengal, British India*). **Axle Boxes.** (5 *Figs.*) May 24, 1917.—This invention consists in improved means for effecting lubrication of the journals of axles in the axle-boxes of railway and tramway rolling-stock. According to this invention, there is mounted in the axle-box, what is referred to as an "adapter plate" A, which is made so that it forms spaces *a* for

Fig 1 Fig.2.



holding fibrous material D to support it in contact with the journal and also forms below it, in the axle-box, spaces or pockets B alternating with the spaces above for the fibrous material, the spaces or pockets B containing reserve oil, which, as the oil becomes used up from the fibrous material will pass through perforations in the adapter plate A. The spaces or pockets B constitute a reservoir in which oil in excess of the maximum saturation limit of the fibrous material can be carried without loss, and from which such oil will, by the capillary attraction of the fibrous material, maintain the said material, in a state of saturation, and after all the reserve oil is exhausted the fibrous material will still be in a condition to afford efficient lubrication for a considerable time. The adapter plate A can be inserted through an opening C (provided with a cover) in the front part of the axle-box and the adapter plate preferably has sufficient outward spring to exert enough pressure on the walls of the box to retain the adapter plate in position. (*Accepted April* 17, 1918.)

105,241. D. H. Pettingell, Golconda, U.S.A. Railway Rail Chairs. (4 *Figs.*) March 28, 1916.—The improved chair comprises a baseplate 3 formed with a channel for the reception of the lower ball of a double ball rail 1, one side 7 of the channel being extended or continued upwards to lie against the web of the rail to serve as a fishplate, and a separate complementing fishplate 14 applied to the opposite side of the rail web and having a depending wedge portion 16 insertible into the channel to secure the rail base. Brace members are also associated with the fish-

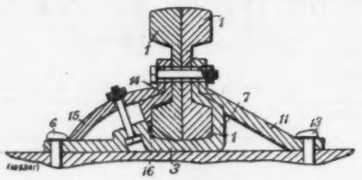
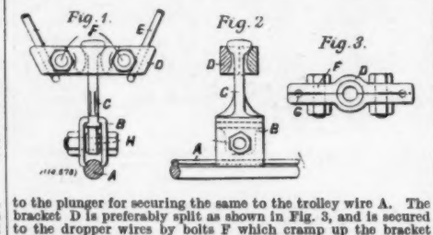


plate members, and secured as hereinafter described. The chair rests upon the underlying ties 4 is provided adjacent one edge with spike openings through which spikes 6 are driven into the ties. Integral with the upper edge of the side 7 of the channel is an inclined brace 11, having its lower edge provided with spike openings through which spikes 13 are driven into the ties. Integral with the fishplate 14 is an arcivate brace 15, the lower edge of which rests upon the baseplate 3 adjacent the spikes 6. (*Accepted April* 17, 1918.)

114,578. P. Dawson, F. W. Fawdry, and H. W. H. Richards, London. Electric Trolley Wires. (3 *Figs.*) September 24, 1917.—This invention relates to an improved supporting device for overhead trolley wires. The invention consists in a trolley wire supporting device having in combination a bracket member D, means for clamping said member to two dropper wires E, a gland in the bracket member having outwardly-flaring or chamfered ends, a headed rod or plunger C whose head is supported by the sides of the gland, and a clip device B attached

Fig. 1. Fig. 2 Fig. 3.



to the plunger for securing the same to the trolley wire A. The bracket D is preferably split as shown in Fig. 3, and is secured to the dropper wires by bolts F which cramp up the bracket parts upon the wires E which pass down the spaces G. The central part of the bracket is formed with a circular hole or gland the sides of which are chamfered, as shown in Fig. 1, to allow a certain amount of swing in any direction to the plunger C, terminates in an eye, through which passes a bolt H, said bolt locking the clip jaws B firmly into contact with the trolley wire A and shank of the plunger C. (*Accepted April* 17, 1918.)

SHIPS AND NAUTICAL APPLIANCES.

114,536. The B. R. Vickers (Leeds) Engineering Company, Limited, Leeds, and A. J. Lebeda, Leeds. Stern Tubes. (6 *Figs.*) June 21, 1917.—This invention, which relates to oil-retaining stern tubes, consists in making provision whereby, while the oil supply may be retained within the stern tube, water can be circulated for the purpose of cooling bearing parts which become heated. In Fig. 1, A designates a tail shaft, B a stern tube, fitted with an oil-supply pipe C, an air pipe D and a drain pipe E. The stern tube B is fitted with bushes, and at its ends with oil-retaining packing devices F, F1. In the aft end of the stern tube B a cylindrical bore is formed, into which a bearing bush G is inserted, the forward end of this bush may abut against

Fig. 1.

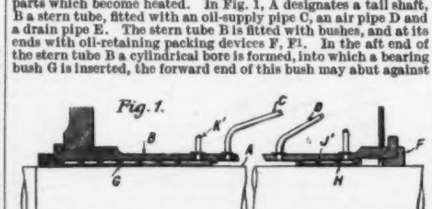
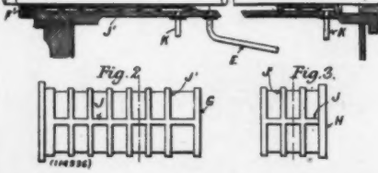


Fig. 2. Fig. 3.



a shoulder in the bore, or the aft end of the bush may be flanged, or, as shown, both arrangements may be adopted. At the forward end of the stern tube the stuffing-box and gland F are provided, and aft thereof the tube is bored to receive a bearing bush H. The exterior of each of the bushes G, H, is formed with peripheral portions, which fit against the surface of the bore in the stern tube B, of sufficient area to afford the support necessary for the bush to act as a bearing for the shaft A, and recesses are formed between the peripheral portions, which in conjunction with the interior of the bore in the stern tube, when the bush is inserted, produce a series of compartments. The adjacent compartments communicate by means of passages extending through or past the peripheral portions, the communications being such that water admitted to one compartment may in succession pass into the next, and so on throughout the whole series. The peripheral portions consist of two longitudinal ribs J associated with transverse circular ribs J1, and the bushes are inserted so that the longitudinal ribs J lie at the sides midway between the top and bottom of the bore. A supply pipe K is connected with the compartment, thus formed at the forward lower end of each bush, and water admitted thereto is free to pass in succession through the compartments until the compartment at the aft lower end is reached, and from there pass into the aft upper end compartment and then in succession until the forward upper end compartment is reached, and from there into a discharge pipe K1. (*Accepted April* 17, 1918.)

TEXTILE MACHINERY.

114,239. O. W. Porritt, Helmshore. Shuttles. (3 *Figs.*) May 29, 1917.—This invention relates to shuttles such as are employed in weaving heavy woollen goods. The shuttle A is of ordinary construction or with the wheels or rollers B mounted on elastic or resilient bearings. According to this invention, the shuttle A is constructed with a hole or aperture *a* in the wall of the shuttle and with a bracket D fitted to it at or near the front and opposite to the aperture *a*. The eye is formed in two

Fig. 1.

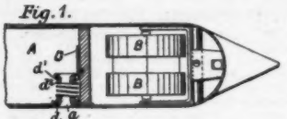
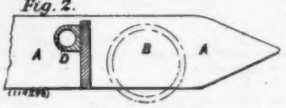


Fig. 2.



cylindrical parts *d*, *d*1, one of which is fitted into a hole or socket in the bracket D and the other into the aperture *a* in the wall of the shuttle. A spiral spring *d*2 in compression is inserted between the two parts *d*, *d*1 of the eye to retain them in position. The thread from the cop in the shuttle is passed through the two parts of the eye *d*, *d*1, and through the spring which holds them in position. By compressing the spring the parts of the eye may be removed and replaced when required. (*Accepted April* 4, 1918.)

114,393. W. M. Angus, Newcastle-on-Tyne, and G. Lunney, Bentham. Warp-Delivering Mechanism. (2 *Figs.*) September 19, 1917.—This invention relates to looms, more particularly those adapted for weaving coarse counts, of the type in which the yarn is passed over gripping rollers rotated from a going part of the loom. According to the present invention, the warp passes over the surface of three rollers, all of which are geared together. In consequence, each roller is positively driven. The different ends of the longitudinal warp yarn A are carried through a reed B, round shafts C and D, through gripping delivery rollers E, F and G, the yarn being gripped between rollers F and E, and F and G, round tension roller H, and so direct to the healds. The roller F is preferably faced with indiarubber. In order that the rollers F, E and G may deliver the yarn at the speed required

Fig. 1.

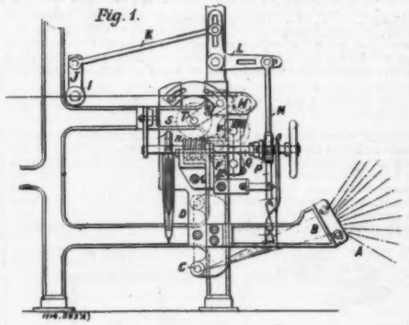
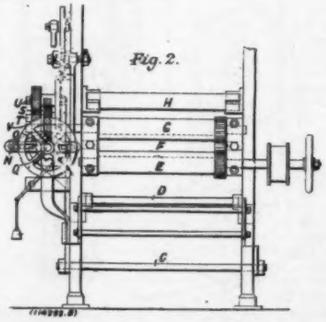


Fig. 2.



by the thickness of weft being used and the number of picks per inch required in the cloth, they are driven through reduction gearing from an oscillating shaft I which operates lever J, which, through link K, operates lever L which, in turn, operates link M and, through this, lever N (Fig. 2). This operates pawl O, which works on ratchet wheel P, which turns shaft Q, which carries the worm R. This worm drives worm wheel S (Fig. 2), with which is compounded driving wheel on the shaft T, which, in turn, drives the geared intermediate wheel on the shaft U. This intermediate wheel turns a geared wheel, which is keyed to the shaft V of the roller G, and causes it to revolve. Roller G at its opposite end is geared to rollers F and E (as shown in Fig. 2) so that all three rollers revolve in unison and deliver the yarn forward to the loom. (*Accepted April* 10, 1918.)

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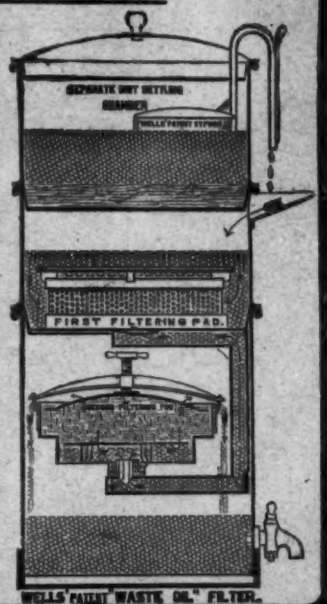

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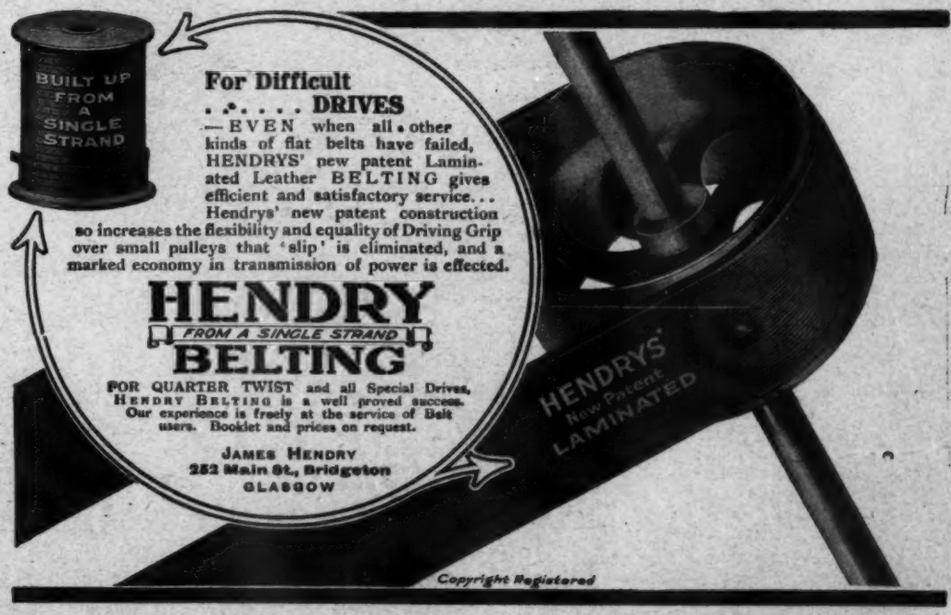

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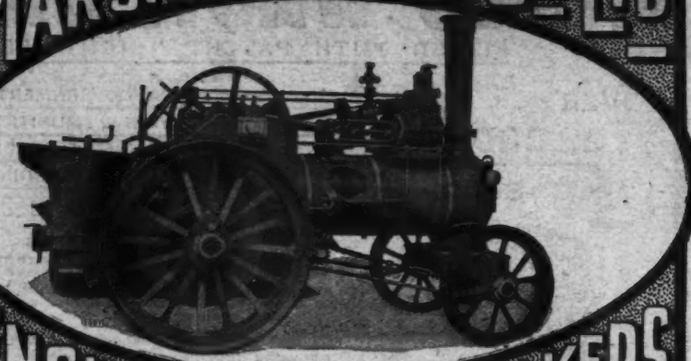

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